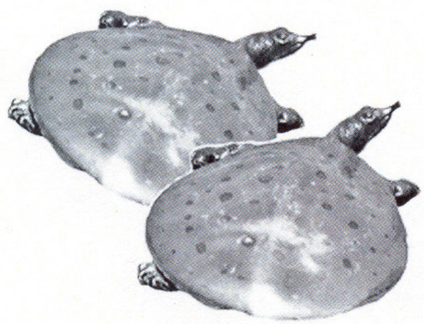
Vermont

Eastern Spiny Softshell Turtle

Recovery Plan

January 2009



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EXECUTIVE SUMMARY

Authority and responsibility for the development and implementation of species recovery plans in Vermont rests with the Secretary of the Agency of Natural Resources and the Commissioner of the Fish and Wildlife Department. The Vermont Endangered Species Law establishes authority for the protection of those species and their respective habitats that are listed as endangered or threatened. Recovery of species listed pursuant to this law is contemplated as a primary objective. Ultimately, the goal of the State of Vermont is to recover species listed under the Vermont Endangered Species Law to a level that they can be delisted and support viable populations for the long-term survival and integrity of the species.

Vermont's Wildlife Action Plan (WAP) (2005), provides a comprehensive evaluation of Species of Greatest Conservation Need (SGCN). Development of this action plan establishes a process of setting conservation priorities for species identified as requiring attention. The spiny soft-shell turtle is included in the list of SGCN. The recommendations established in this recovery plan are in keeping with the broader recommendations in the WAP.

This State Recovery Plan identifies effective actions that will contribute to the conservation and recovery of the state-threatened Eastern spiny softshell turtle (*Apalone spinifera spinifera*) in Vermont. It outlines population assessment and monitoring needs for tracking changes in distribution and abundance of the population as well as for determining success or failure of the recovery effort.

The Eastern spiny softshell turtle is a medium to large aquatic turtle found in Lake Champlain and the lower reaches of some tributaries with concentrations occurring in Missisquoi Bay and the Lamoille River in Vermont. Unlike other turtles, the spiny soft-shell turtle has a leathery, pliant shell. Spiny softshell turtles utilize a variety of habitats to fulfill daily and seasonal requirements: soft-bottomed and vegetated aquatic areas for foraging and escape cover; exposed rocks and logs for basking; relatively vegetation-free sandbars and shale pebble-gravel beaches that are well-drained and have adequate solar exposure for nesting; and underwater hibernacula that provide well-oxygenated water and are free of ice scour and disturbance. The Vermont soft-shell turtle population is estimated to be 200-300 individuals and is thought to be disjunct from other populations in the Great Lakes and Mississippi drainage.

Direct loss and degradation of nesting, basking, and wintering habitat, nest predation on eggs and young, possible boat strike and fishing mortality, and human disturbance threaten the long-term viability of Lake Champlain's softshell population. Listed as state-threatened in 1987, historic decline, small population size, and continued threats to survival of spiny softshell turtles were cited as reasons supporting listing. Spiny softshell turtles were nationally listed as threatened in Canada in 1991 and officially listed as threatened in Québec in 1999. The management of the Lake Champlain spiny soft-shell turtle population is a shared responsibility of Québec and Vermont because the population uses both United States and Canadian waters, wetlands, and shoreline habitats and is affected by human activities in both countries. Softshell turtle conservation efforts have benefited from the involvement of many organizations and international cooperation. Partners from both Québec and Vermont have worked together on monitoring and management projects and share information about spiny softshell turtles in Lake Champlain.

This document provides an overview of spiny soft-shell turtle biology, population condition, threats, research needs, and ongoing management efforts specific to Lake Champlain's spiny softshell turtle population. It also provides a comprehensive recovery plan that lists those actions identified as most likely to ensure the long-term viability and growth of Lake Champlain's spiny softshell turtle population. The goal is to recover Vermont's spiny softshell turtle population to a sustainable and secure population level that will justify de-listing from the Vermont list of endangered and threatened species. Management actions recommended focus on increasing population recruitment, identifying additional critical habitat areas, protecting and enhancing habitat, and raising public awareness of and appreciation for the spiny softshell turtle.

I. TAXONOMY, SPECIES DESCRIPTION AND DISTINGUISHING FEATURES

Spiny softshell turtles are in the family Trionychidae. They are known from the Jurassic Period (210 to 144 million years B.P.) and are found today in North America, Africa, Asia, and the Indo-Australian archipelago (Ernst et al. 1994). The eastern spiny softshell turtle (*Apalone spinifera spinifera*), previously known as *Trionyx spiniferus spiniferus*, is the only species in this family found in Vermont. Several other subspecies are known from North America. Lake Champlain spiny softshell turtles may be genetically unique (Weisrock and Janzen 2000).

The eastern spiny softshell is a medium to large turtle. It has a flattened, leathery carapace that is olive to grayish in background color with numerous dark, often ocellated (eye-like) spots with a single dark line concentric with the margin and bordering a wider, light outer band. These spots increase in size toward the center of the shell. The anterior margin of the carapace is studded with prominent tubercles. The entire surface of the carapace, or at least it's anterior and posterior sections, are roughened by small, sharp projections that impart a sandpaper-like surface (Carr 1952, Ernst et al. 1994). The distinctive shell, large and three-clawed webbed feet, and a tubular snout easily distinguish this species from all other turtle species found in Vermont.

There is marked disparity in the sizes of the sexes. Females reach a maximum carapace length of 54 cm (21.3 in) and weigh up to 11.7 kg (25.75 lb) whereas males reach a maximum carapace length of about 21.6 cm (8.5 in). The largest female softshell turtles recorded from Vermont include a female caught in the Missisquoi River in 1998 that had a carapace length of 39.7 cm (15.9 in) and weighed 4.6 kg (10.2 lbs) and a female captured in Missisquoi Bay in 2000 that had a carapace length of 38.5 cm (15.4 in) and weighed 4.9 kg (10.8 lbs) (Galois et al. 2002). The largest male recorded from Vermont was captured in the Missisquoi River in 1998; it measured 17.4 cm (7.0 in) in carapace length and weighed 0.525 kg (1.2 lbs) (Normandeau Associates Inc. unpubl. data). Females average 1.6 times larger than males (Oldham et al. 1996). Hatchlings typically measure between 3-4 cm (1.2-1.6 in) in carapace length and weigh about 8 to 10 grams (about 0.3 oz) (Ernst et al. 1994).

The coloration of the males is often strikingly different from that of females because males tend to retain the juvenile markings of spots and lines while females acquire, with advancing age, a blotched or mottled carapace (Carr 1952). Hatchlings resemble adult males in shape, color, and pattern. However, development of sex-specific differences in carapace marking pattern begins at a carapace length of as little as 5.2 cm (2.1 in) (Graham 1991). Spots on hatchling males are bordered by a distinct dark ring while those on females have either an indistinct ring or no ring at all around them (Graham and Cobb 1998). These differences in pigmentation patterns between males and females have been observed in Vermont hatchlings (S. Parren pers. obser.).

II. DISTRIBUTION

Historical Distribution

The arrival of the spiny softshell turtle to Lake Champlain is believed to have occurred towards the end of the last glaciation, approximately 10,000 years B.P., during the era of the Champlain Sea (Ministère de l'environnement et de la faune. 1997). Archaeological remains discovered at Pointe du Buisson in Melocheville have established its presence in the St. Lawrence River to approximately 900 years ago. Remains prior to 1760 have been discovered at Pointe-à-Callière in Old Montreal and from before 1665 until 1765 at Fort Chambly on the Richelieu River (Québec Eastern Spiny Softshell Recovery Team 2001).

Spiny softshell turtles were first reported in Lake Champlain by Thompson (1853). In August of 1844, a specimen was taken from the Lamoille River and several specimens were taken from or near the mouth of the Winooski River. This led the author to conclude that a breeding population was likely at that location (Thompson 1853). Babbitt (1936) considered these turtles to be very rare in Lake Champlain and anecdotally attributed their rarity to hooking mortality, nest predation, and pollution from cities near the mouth of the Winooski River.

Two historic sightings in New York were along the Mohawk River (near Albany, 1842 and 1936) (Vermont Reptile and Amphibian Scientific Advisory Group 1999). It is unknown whether a Mohawk River population ever existed. No spiny softshell turtles were found there during surveys accompanying New York's recent atlas effort (A. Breisch pers. comm.).

Scattered sightings in Québec during the 20th century suggest that spiny softshell turtles inhabited the Ottawa River, Lac des Deux Montagnes, Lac Saint-François, Lac Saint-Louis, Lac Saint-Pierre, the Richelieu River and the Yamaska River. It is believed that softshell turtles in Québec are presently restricted to Lake Champlain (Ministère de l'environnement et de la faune. 1997).

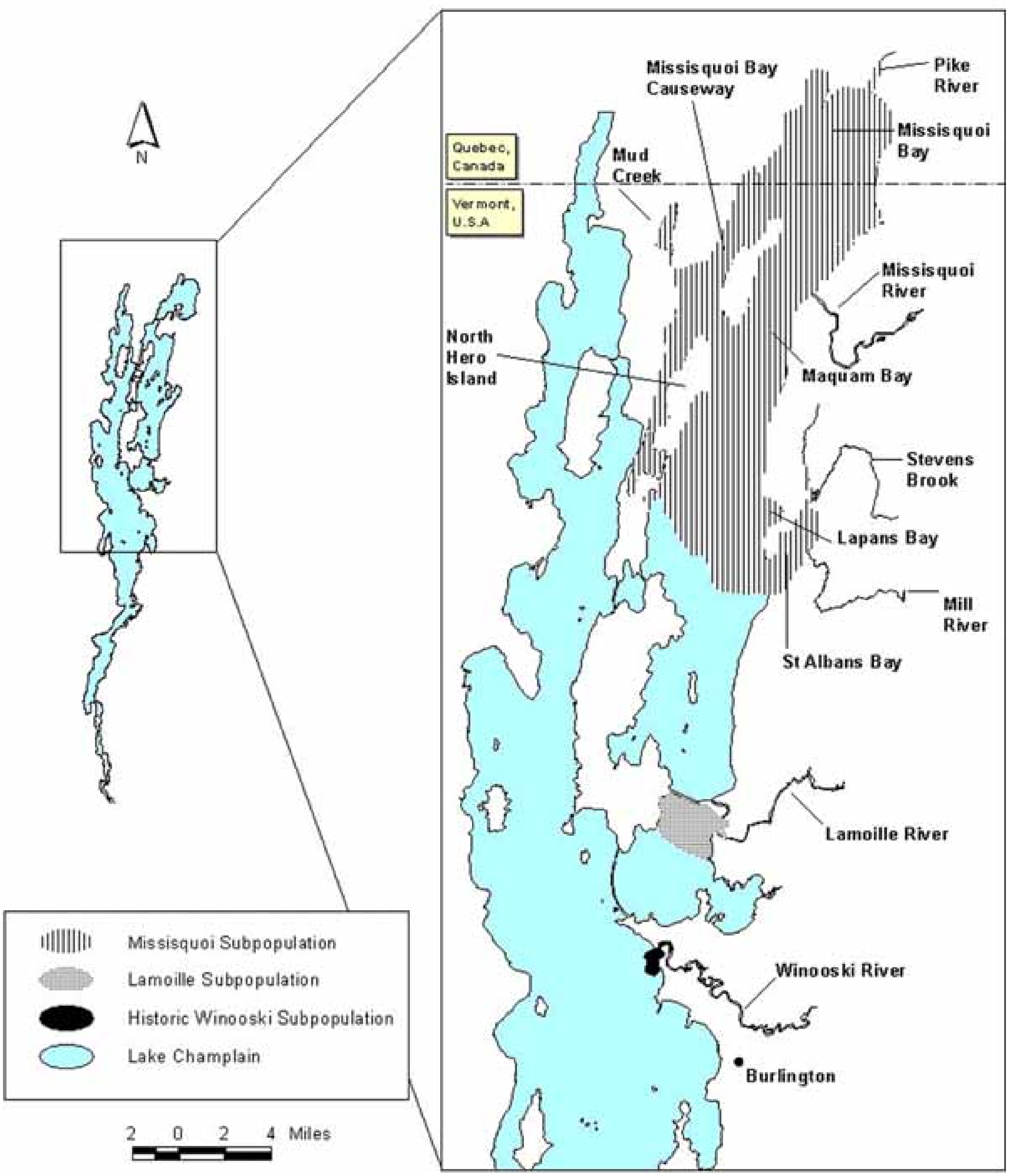
While population data quantifying past abundance of softshell turtles in the region does not exist, it is clear that the spiny softshell turtle no longer occurs in parts of its former range within both Québec and Vermont. Habitat loss has been cited as one of the primary causes of population declines in land and freshwater turtles: freshwater wetlands worldwide are the most endangered of ecosystems and reducing reproductive success by loss of suitable nesting habitat can quickly reduce population sizes and alter population structures (Mitchell and Klemens 2000).

Current Distribution

Spiny softshell turtles in Lake Champlain are currently concentrated in and near the lower Lamoille River and Missisquoi Bay (Fig. 1). The Missisquoi concentration is believed to include animals using the Pike River and Chapman Bay in Québec and the Missisquoi River, Mud Creek, North Hero, McQuam Shore, Lapan's Bay, and St. Albans Bay in Vermont. It is unknown whether gene flow between the Missisquoi and Lamoille areas of concentration currently occurs, and they could represent distinct subpopulations. The mouth of the Lamoille River is more than 18 km (11 mi) from St. Albans Bay and nearly 48 km (30 mi) from Missisquoi Bay. There has been no documentation of tagged turtles moving between the Lamoille River and Saint Albans or Missisquoi bays.

The three disjunct populations in Ontario (Long Point National Wildlife Area, Rondeau Provincial Park, and Thames River) are well removed from the populations associated with Lake Champlain (Oldham et al. 1996). In New York, spiny softshell turtles are found in Sodus Bay, Lake Ontario, the Allegheny and Genesee rivers, and most of the Finger Lakes (A. Breisch pers. comm.). No population has ever been documented on the New York side of Lake Champlain. No other populations are known to exist in New England or Québec. The Lake Champlain population is considered disjunct from other spiny softshell turtle populations in the Great Lakes and Mississippi drainage (Galois et al. 2002). The spiny softshell turtle is found elsewhere in North America, existing within a large area that extends from western New York and southern Ontario westward to eastern Wyoming and southward to the Gulf of Mexico (Ernst et al. 1994).

Figure 1. Eastern Spiny Softshell Subpopulations of Lake Champlain Vermont, U.S.A and Quebec, Canada



III. POPULATION STATUS

In 1987, spiny softshell turtles were state-listed as threatened in Vermont due to historic decline in Vermont and in the region as indicated by loss of watersheds occupied by a subpopulation associated with the Winooski River (Winooski River area), small population size and "threats". No data documenting decreases in population numbers was cited at that time. The population of spiny softshell turtles in Lake Champlain is believed to be relatively small. Although no valid estimates exist, it is believed that the population numbers less than 300 adults and large juveniles. At the time of the species listing, small population size was thought to present a continued challenge to survival of this species in Vermont. Spiny softshell turtles were nationally listed as threatened in Canada during 1991 and officially listed as threatened in Québec in 2000. Softshell turtles currently persist in Lake Champlain as a small subpopulation in the Lamoille River area of Vermont and as a somewhat larger subpopulation at the northern end of the lake in both Vermont and Québec. Spiny softshell turtles no longer are found in the Winooski River in Vermont while Québec has lost all populations (Figure 1) except the Lake Champlain population.

Spiny softshell turtles in the lower Lamoille River are estimated to number about 60 (35-115) individuals (Graham and Graham 1997). Rough estimates of spiny softshell turtles in the Missisquoi Bay area ranges from 100 (Ministère de l'environnement et de la faune. 1997) to ~200 (S. Parren pers. comm.). A mark and recapture estimate using PIT (Passive Integrated Transponders) tags provided an estimate of 124 individuals utilizing the Missisquoi Bay causeway during winter (Normandeau 2001). No confidence interval was reported. Fifty-nine different turtles tagged with PIT and radio tags were detected in the vicinity of the causeway between 1997 and 2004. A total of 97 individuals had been tagged in the Missisquoi Bay area between 1996 and 2004, but their locations in the fall and winter were not always known. By the spring of 2003, 19 of 22 (86%) tagged female spiny softshell turtles had used the Missisquoi Bay causeway hibernaculum. The ratio of males to females at the causeway area in the fall is about 1:4, so the estimate of 124 total turtles using the area could represent 93 females and 31 males. If approximately 100 females at the bridge during the winter make up 86% of all Missisquoi Bay females, the total number of females using the Bay is likely between 100 and 200. Because these estimates are uncertain, indices of population change may need to be used to assess population trends. No historical population estimate exists however, spiny softshell turtles do not currently occupy parts of its range formerly occupied in both Vermont and Québec.

IV. NATURAL HISTORY AND ECOLOGY OF THE SPECIES

Feeding Habits

Spiny softshell turtles are primarily benthic feeders (Williams and Christiansen 1981) and actively seek food by probing along the bottom, beneath objects, or in clumps of submerged vegetation. They may also conceal themselves on the bottom in mud or sand and ambush passing prey animals with quick thrusts of their long necks (Harding 1997). Spiny softshell turtles are predominantly carnivorous, feeding on crayfish, aquatic insects, mollusks, earthworms, tadpoles, frogs, minnows and other organisms (Ernst and Barbour 1972, Oldham et al. 1996). Of 11 spiny softshell stomachs examined in Michigan, 47% contained crayfish and 52% contained insects (Lagler 1943). Penn

(1950) reported that crayfish made up as much as 46% by volume (58% by frequency) of stomach contents. In Iowa, Williams and Christiansen (1981) found that 55% of spiny softshell stomachs (n=52) contained crayfish. In Missouri, Anderson (1965) found crayfish in 61%, insects in 35%, and fish in 2% of 11 stomachs. Mayfly larvae and dragonfly nymphs comprised roughly 42% each of the diet of spiny softshell turtles in the upper Mississippi (Cochran 1977 in Campbell and Donaldson 1980). Spiny softshell turtles will eat worms and minnows. This behavior has resulted in hooking by anglers (M. Lyttle pers. comm.). Vegetation appears to be a minimal part of their diet (Carr 1952).

Reproduction

Male spiny softshell turtles become sexually mature at shell lengths of 9-10 cm (3.5-3.9 in). Females become sexually mature at shell lengths of 18-20 cm (7.0-7.9 in) (Ernst et al. 1994) when approximately 12 years of age (Oldham et al. 1996). Turtles in northern populations tend to grow larger and mature later than turtles in southern populations (Galbraith et al.1989, Brooks et al. 1992, St. Clair et al. 1994). For this reason, spiny softshell turtles in Lake Champlain are probably larger and older than their southern counterparts before reaching sexual maturity.

Mating is reported to occur in April or May (Ernst et al. 1994) but has been observed in August (Galois et al. 2002). Cool spring temperatures or high water levels that temporarily submerge nesting substrate can result in delayed nesting. Two females were photographed nesting on a northern Vermont beach on May 27, 1998 (R. Kilburn pers. comm.). Fletcher (1998) reported the first recorded nest in southwestern Ontario was constructed on May 28, nearly three weeks earlier than the previous year. Graham and Graham (1997) found that nest building and egg deposition occurred over a period of about four weeks (June 15 to July 12). A radio-tagged female was observed nesting on June 14, 1999 (Galois et al. 2002). In 2000, spiny softshell turtles were observed on a Vermont nesting beach between June 19 and July 16, 2000 (Freeman 2000).

Nests are usually excavated within 100 m (328 ft) of the shoreline in sand or gravel substrate and where there is little to no vegetation growing (Vogt 1981a in Ernst et al. 1994). Daigle et al. (2002) described nest building by a female that excavated a nest 2 m (6.6 ft) from the Pike River and approximately 1 m (3.3 ft) above the water level. Excavation occurred at the edge of vegetation in gravel substrate. The vigor with which digging occurred was reported to be notable. Excavation, from start to finish, lasted approximately 44 minutes.

Documented nest sites for the Lamoille River population were observed to be 1-5 m (3.3-16.4 ft) from the water in substrate of fine sand or coarse sand intermixed with gravel in the lower portion of the river (Graham and Graham 1997). Upstream nests tended to be further from water (>10 m or 33 ft), possibly to avoid inundation during rainstorm-associated flooding. Other Lake Champlain nests have been located even further from water (but always <100 m or 328 ft). The substrate often consists of gravel composed of flat shale fragments with about 50% of the material having a diameter of 6-13 mm (0.25-0.50 in) along the long axis (S. Parren pers. obser.). Nests are flask-shaped with a 2.5-3.8 cm (1-1.5 in) diameter neck and a main cavity that ranges 7.6-12.7 cm (3-5 in) in diameter and 10.2-25.4 cm (4-10 in) in depth (Carr 1952).

Females in the northern part of their range typically lay a single clutch of eggs. Eggs are rigid, heavily calcified, and average 20 per nest (range 4-32) (Ernst et al. 1994). Graham and Graham (1997) observed 14 nests along the Lamoille River and reported an average clutch size of 16.2 (13-21). Clutch size in turtles is positively correlated with body size. Usually small numbers of eggs in nests indicates small females nesting in their first nesting season (Plummer 1977b, Congdon and Gibbons 1985).

Ernst et al. (1994) reported that incubation typically lasts 82-84 days with hatchlings emerging from late August into October. However, incubation has been found to vary as a function of temperature ranging from <52 to >95 days: in Wisconsin, 25-25.5˚C (77-77.9˚F) resulted in an incubation period of 95.4 days; 25-30˚C (77-86˚F), 69.0 days; 29.5-30˚C (85.1-86˚F), 57.9 days; mostly above 30˚C(>86˚F), 52.2 days (Ernst et al. 1994).

Janzen (1993) found the smooth softshell turtle's (*Apalone mutica)* length of incubation increased exponentially as temperature decreased and that hatchlings from cooler incubation temperatures (26˚C or 79˚F) were usually smaller than those from warmer incubation temperatures (30˚C or 86˚F). The size of hatchlings is also believed to be influenced by size and quality of eggs, however, no relationship appears to exist between body mass and either placement of the eggs or hydric conditions (Packard et al. 1981).

Unlike some other turtle species, spiny softshell turtle hatchlings cannot survive tissue freezing and must emerge from their natal nests in autumn to hibernate under water (Costanzo et al. 1995). This emergence timing is considered to be the norm in northern populations. Successful over-wintering in the nest is believed to be rare. Along the Lamoille River, four nests left to over-winter failed to produce hatchlings the following spring. It is uncertain whether nest failure was caused by inundation or freezing (Graham and Graham 1997). In contrast to most other turtles, spiny softshell turtles are not temperature-dependent sex determinate. Sex ratios at birth are about 1:1 (Bull and Vogt 1979, Vogt and Bull 1982).

Basking Behavior

Spiny softshell turtles emerge from the water or move into shallow water to sun themselves. This behavior is called basking. Basking is believed to be an important behavior of the spiny softshell turtle in the northern part of its range. For this cold-blooded species (ectotherm), digestion, egg maturation, and immune system response (Cooper et al. 1985) are functions that depend on solar energy. Turtles seek basking sites where sunlight acts to raise their body temperature on warm and sunny days (Plummer 1977a). Swimming at the surface has been observed at the Missisquoi Bay causeway as late as November 4 (Galois 1998).

Spiny softshell turtles emerge from the water in sheltered places and bask in the sun for hours at a time. They sometimes congregate in large numbers in a favored spot (Carr 1952). Spiny softshell turtles prefer to remain close to the water with legs and plastron submerged (Graham and Graham 1997). Spiny softshell turtles tend not to emerge to bask on cool, windy days (Brattstrom 1965), but will bask in shallow water on cool, sunny days in locations where they are protected from the wind (P. Galois pers. obser.). Thermal benefits are also gained through basking in shallow water either on submerged vegetation or burrowed in sandy bottom substrate. Graham and Graham (1991) found the average temperature of four daytime burrows to be as high as 30.5˚C (87˚F) while the temperature of the lake water 20 m (66 ft) away was 22˚C (72˚F). Galois et al. (2002) radio-tagged 14 female and 7 male spiny softshell turtles and monitored their movements in northern Lake Champlain between 1996 and 1999. Basking was observed a total of 71 times out of 671 telemetry locations: 56% on shore, 20% on a tree trunk, 14% on a rock, and 10% on floating vegetation. Along the Lamoille River, partially submerged dead tree trunks were the preferred basking substrate (Graham and Graham 1997). Spiny softshell turtles also utilize manmade structures for basking, including rock causeways (Normandeau 2001; Galois et al. 2002) and floating platforms (A. Breisch pers. comm., Vanasse Hangen Brustlin and Normandeau 2004).

The primary function of basking in aquatic turtles is thermoregulatory (Gans and Pough 1982). In addition to raising body temperature, the benefits of basking by turtles may include elimination of ectoparasites, elimination of epizoic algae from the carapace, drying the integument to reduce bacterial and fungal infections, synthesis of vitamin D associated with calcium metabolism, enhanced digestive efficiency and rate, increased fat mobilization, and increased rate of follicle development (Congdon 1989). Koper and Brooks (2000) reported that growth in painted turtles (*Chrysemys picta*) was positively correlated with basking frequency but not with quantity of food provided. They concluded that growth was affected by the availability of basking opportunities. "Turtles are ectotherms that require external heat sources to maintain proper physiological activity and to ward off disease, and basking sites are often vital to their well-being" (Seigel and Dodd 2000).

Over-wintering Behavior

Spiny softshell turtles in Lake Champlain hibernate approximately six months out of the year (Lyttle 1999). Movement to over-wintering sites begins in late August. In Missisquoi Bay, female softshell turtles are known to travel up to 20 km (12.4 mi) from the Pike River in Québec to the Missisquoi Bay causeway area in Vermont to over-winter (Fig. 1). Radio-tagging has also demonstrated that females move from Chapman Bay, Missisquoi River, and Big Bluff areas to the causeway (Normandeau 2001, Galois et al. 2002). All turtles usually enter hibernation by early October. During hibernation, turtles may be buried under 5-10 cm (1.9-3.9 in) of bottom substrate with only the head and neck protruding into the water column (Ernst et al. 1994). Spiny softshell turtles can tolerate this prolonged cold submergence in normoxic (oxygen-saturated) water by depressing their metabolic rate and supporting their metabolism aerobically via extrapulmonary mechanisms i.e., pharyngeal, cloacal, and cutaneous underwater respiration (Ultsch and Jackson 1995, Crocker et al. 2000). By remaining aerobic throughout the winter, the production of lactate is minimized and submergence time may then be prolonged (Crocker et al. 2000, Prassack et al. 2001). Because an aerobic metabolism requires well-oxygenated water, this species is relatively intolerant of anoxic (oxygen-depleted) submergence (Ultsch and Jackson 1995) and is thought to be restricted to well-oxygenated, permanent bodies of water (Stone et al. 1992).

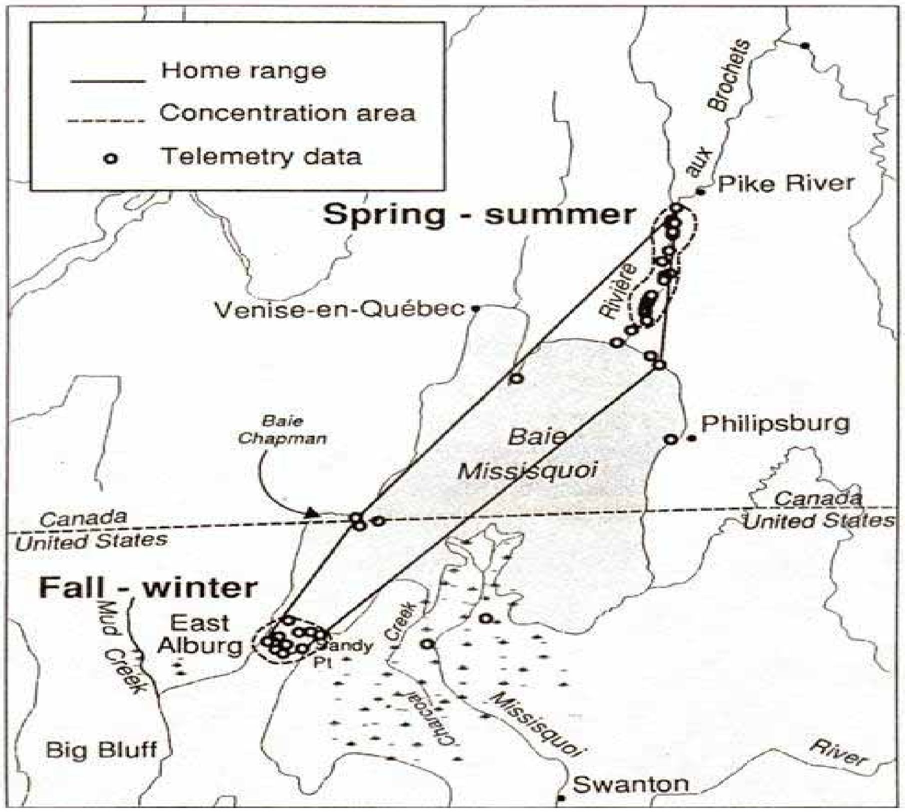
Several hibernacula are known to exist in Lake Champlain: near the Missisquoi Bay causeway, Missisquoi River near Swanton, Missisquoi River delta, and lower Lamoille River (Graham and Graham 1997, Galois et al. 2002). The Missisquoi Bay causeway hibernaculum is large and may support most of the females in the Bay: 19 of 22 females tagged between 1997 and 2002 have used the site (S. Parren pers. comm.). One female has been detected in the Missisquoi River near Swanton, males use the Missisquoi delta site, and a smaller population uses the Lamoille River. In the winter of 2002/2003, one female was located 0.80 km (0.5 mi) south of the causeway along the Alburg shore at a depth of 5.5 m (18 ft). A second female was found about 2.4 km (1.5 mi) south of the causeway, well away from shore and at a depth of 6.7 m (22 ft). In the Lamoille River, Graham and Graham (1992, 1997) observed spiny softshell turtle gathering in a deep (6-7 m or 20-23 ft) depression in the river bottom. From November of 1997 to March of 1998, oxygen levels at this site remained high and were consistently close (>90%) to air saturation value while the water temperature remained stable at 1˚C (34˚F) (Crocker et al. 2000). Current on the bottom was almost undetectable (Graham and Graham 1997). Normandeau (2001) found similar results with regards to hibernacula characteristics: relatively deep water (Lamoille River 5 m [16 ft], Missisquoi Bay causeway 5 m [16 ft], Missisquoi River near Swanton 4 m [13 ft]) that is well oxygenated (D.O. ≥ 10 ppm) with a bottom sediment of silty to coarse sand. Compared to the Lamoille River site and the Missisquoi River sites, the water temperature at the causeway was warmer: data collected during January, February, and March show the causeway water temperature was often greater than 2˚C (36˚F) while at other hibernacula it was only slightly above 0˚C (32˚F) (Normandeau 2001).

Spiny softshell turtles in Lake Champlain appear to exhibit site fidelity to hibernacula although one turtle for which consecutive year data was available showed alternative wintering site use, switching from a location south of the causeway to the causeway area (R. Simmons pers. comm.). Graham and Graham (1997) concluded that most spiny softshell turtles in the lower Lamoille River use the same hibernation site based upon observations made while scuba diving and through monitoring of radio-tagged individuals over a period of years (1989-1995). Lyttle (1999) reported that all females with radio-transmitters (n=6) used the causeway hibernaculum during the winters of 1998-1999 and 1999-2000. Nine female turtles from the Missisquoi Bay subpopulation that were detected in consecutive winters showed fidelity to the causeway hibernaculum (Galois et al. 2002).

Death will occur if an underwater hibernaculum is exposed to freezing air temperatures due to a drop in the water level during the winter (Ernst et al. 1994). Hibernation typically ends by early May (Graham and Graham 1997) although cold spring weather could extend the hibernation period. Spiny softshell turtles typically remain at the hibernaculum near the Missisquoi Bay causeway until the first week in May (R. Simmons pers. comm.).

Movements

Figure 2. Radio-tracked movements of spiny softshell turtles in northern Lake Champlain, Vermont and Canada (1996-1998). Map courtesy of Galois et al. 2002.



Spiny softshell turtles are good swimmers capable of frequent and long movements. Pace et al. (2001) reported mean and maximum swimming speeds of 3.4 and 4.1 body lengths per second, respectively. A high proportion of Plummer's (1977b) adult female recaptures were found at nest sites up to 6 km (3.7 mi) from the main study area and all (n=3) hatchling recaptures were found 4 km (2.5 mi) downstream three days after their release. Lake Champlain spiny soft-shell turtles have also been documented traveling long distances, particularly in early May and late August, when movement between the nesting and summer areas and the over-wintering site occurs (Graham and Graham 1997, Lyttle 1999, Galois et al. 2002, Daigle et al. 2002). For example, three females using the Pike River in the summer over-wintered at the causeway 20 km (12.4 mi) south (Galois et al. 2002, Fig. 2). Softshell home ranges in Lake Champlain are large with spring-summer and fall-winter activity centers. Galois et al. (2002) found males to have smaller home ranges relative to females. Most home ranges included two centers of activity that corresponded to different periods of time (Table 1).

Table 1. Mean size of annual and seasonal home range for female and male eastern spiny softshell turtles in Lake Champlain (Galois et al. 2002).

	Females (n=11)	Males (n=4)
Mean Home Range Size	32.06 km^2 (range 1.77-110.28 km^2) or 12.82 mi^2 (range 0.19-68.37 mi^2)	2.75 km^2 (range 0.44-6.92 km^2) or 1.10 mi^2 (range 0.27-4.29 mi^2)

	Females (n=11)	Males (n=2)
Mean Size August-April Period	2.11 km^2 or 0.84 mi^2	0.1 km^2 or 0.04 mi^2
Mean Size May-July Period	0.94 km^2 or 0.38 mi^2	0.675 km^2 or 0.27 mi^2

Longevity, Predation and Other Mortality Factors

Spiny softshell turtles may live to be more than 50 years of age (Ministère de l'environnement et de la faune,1997). Adult spiny softshell turtles have few predators in Lake Champlain.

Spiny softshell turtle nests are vulnerable to predation by raccoons, skunks, red fox, and other mammalian predators (Oldham et al. 1996, Harding 1997). The largest source of egg mortality for both protected and unprotected spiny softshell turtle nests in Ontario during 2003 was predation (de Solla et al. 2003). Raccoons depredated 62% (n = 24) of caged nests and 100% (n = 70) of uncaged nests on a nesting beach in Canada (Fletcher 1998). At Vermont nest sites, raccoons and skunks (Mephitis mephitis) have accounted for most egg predation. As in Canada, red foxes (Vulpes vulpes) have also been documented destroying nests. Gray squirrels (Sciurus carolinensis) are suspected to have dug up softshell eggs at one Vermont site because cameras monitoring a nesting beach recorded the presence of squirrels where intact eggs were excavated and left on the surface (S. Parren pers. obser.).

Spiny softshell turtle nests are also vulnerable to infestations by sarcophagid flies. It is thought that flies locate tunnels created by emerging hatchlings and use the tunnel to reach the remaining turtle eggs and young. The flies then deposit their own eggs in the turtle nest (de Solla et al. 2003). In Ontario, Fletcher (1997 and 1998) observed nests entirely consumed by sarcophagid fly maggots. Among three sites in Ontario, the proportion of protected nests parasitized by flies ranged from 3.6-9.9% (de Solla et al. 2003). Infestation of softshell turtle nests by sarcophagid flies has been detected in Vermont (S. Parren pers. obser.).

Newly hatched and small juvenile spiny softshell turtles are also vulnerable to raccoons as well as other mammals, herons, snakes, other turtles and large fish (Ernst et al. 1994; Harding 1997).

Adult turtles may die as a result of hooking by anglers (Babbitt 1936; Fichtel pers. comm.). However, reports of hooked turtles being released and observations of individuals with a hook and broken line still attached indicate that some spiny softshell turtles may be able to survive these encounters (S. Parren pers. comm.). Boat propellers are also a source of turtle injury and mortality

(Galois and Ouellet 2007). A female softshell turtle was found dead in Pike River. It had deep lacerations attributed to a boat propeller (Galois et al. 2002). Physical trauma caused by scouring ice packs associated with harsh winters may also be a potential source of mortality for hibernating turtles (Plummer 1977a).

Spiny softshell turtles are susceptible to a large variety of parasites (*Balantidium, Cryptospridium, Toxoplasma, Eimeria, Oxyurid,*), fungi (*Dermatophyton, Aspergillus,*), bacteria (*Clostridium, Pseudomonas, Mysobacterium, Actinobacillus, Aeromonas,*), and viruses (*Herpes, Reovirus, Paramyxovirus,*) (Dr. C. Lanthier pers. comm.). None of these infectious agents are specific to spiny softshell turtles. One turtle was discovered dead in a turtle trap in 2000 with cause of death believed to be disease (Normandeau 2001).

V. HABITAT REQUIREMENTS AND STATUS

For this recovery plan, habitat is defined as the area or space within which a species lives and reproduces. Everything that a species needs to survive and reproduce must necessarily be both present and suitable within that species' habitat. Successful recovery of this species is directly related to the availability of suitable habitat for all life stages. This plan emphasizes the identification, conservation, protection and stewardship of essential habitat areas in and along the shoreline of Lake Champlain and associated rivers for successful species recovery.

. Nesting and Incubation Habitat

Although habitat suitability criteria (such as substrate particle size, depth of substrate, percent shading, aspect, slope, among others) for nesting and incubation habitat have not been fully described for the spiny softshell turtle, a great deal is known about these important habitat types. Nesting and incubation is known to occur in well drained sand and gravel soil that is relatively free of vegetation and shading. Although it is not known how soil depth, compaction, and particle size affects suitability of nesting and incubation substrate, eggs have been observed buried to depths of 8.9-15.3 cm (3.5-6 inches). Solar exposure for large portions of the day is necessary for successful incubation of eggs. Although length of incubation and size of hatchlings has been documented to be correlated with incubation temperature in *A. mutica* (Janzen 1993), the amount of solar exposure needed to sustain suitable substrate temperature and incubation conditions has not been described for the spiny softshell turtle. Eggs can not survive extended periods of submersion. It is unlikely that eggs can survive freezing.

Nesting habitat is critical to reproduction of turtles. Nesting habitat occurs on sand and gravel shores of Lake Champlain and tributary streams. These locations are also preferred by people for construction of camps, houses, and other structures as well as for other activities such as lawns, agricultural pastures and fields, swimming, boat launching and other activities. Humans change the shoreline dynamics as their activities change. These changes can affect turtles as described in more detail in the section addressing threats to the population.

A survey of Missisquoi Bay in 1996 determined that of the 27.3 km (17 mi) shoreline, 46% (12.6 km or 7.8 mi) had been converted to concrete and block walls, 32% (8.7 km or 5.4 mi) was occupied by cottages and campgrounds, 11.5% (3.1 km or 2 mi) was rocky escarpment, and only 10.5% (2.9 km or 1.8 mi) was natural (Thompson 1996a, b). Only a fraction of the unaltered shoreline has been protected or managed to either protect or enhance these areas as habitat for turtles.

The Pike River and Province Point in Quebec, the north end of North Hero, Sandy Point at West Swanton, Camp Kiniya, and the Lamoille River have known spiny softshell turtle nesting sites. Nesting at Lapan's Bay was confirmed in 2008. However, adults on shore during the nesting season and the presence of small young is strong evidence of nesting (S. Parren pers. comm.). Big Bluff and Bullrush Point are also suspected to have nesting sites. Clay Point and the Winooski River are believed to have areas that were used historically as nesting sites. There are few records documenting historical use of nesting substrates by spiny softshell turtles along the shores of Lake Champlain and its tributaries.

The following areas are currently known (k), suspected (s), or have historical evidence (h) of use as nesting sites for spiny softshell turtles: Pike River (k), Province Point (k), West Swanton (k), Camp Kiniya (k), Big Bluff (s), north end of North Hero (k), Bullrush Point (s), Lapan's Bay (s k), Lamoille River (k), Clay Point (h), Winooski River (h).

Examination of historical aerial photography has revealed substantial erosion of the shoreline at Sandy Point. Sandy point is a significant state-owned nesting location. Swanson et al. (2001) estimated that the shoreline at Sandy Point eroded by 9 meters (30 feet) between 1941 and 1995. Historical photographs of this site indicate that the shoreline at Sandy Point is today much more vegetated with trees and shrubs than it has been in the past. Historical aerial photographs document that sand and gravel shoreline likely suitable for nesting of spiny softshell turtles may have been reduced or lost in some areas at this site since 1938.

Some of this erosion occurred subsequent to construction of the Missisquoi Bay causeway 1936-1938. Construction of concrete walls and placement of riprap to slow and prevent additional erosion of the shoreline by shoreline property owners has created shoreline obstacles which may make it difficult or impossible for turtles to move from the water to possible nesting sites in some areas. Increase in shading of potential nesting sites by trees and shrubs as well as encouragement of sod for lawns has reduced the amount of suitable substrate having access to direct sunlight and has made some areas unsuitable for nest excavation by turtles.

Assuming that most shorelines and stream banks having sand and gravel substrate with good sun exposure would have been used by nesting turtles, it seems likely that substantial amounts of nesting habitat have been lost or rendered unsuitable for nesting due to development. Significant decreases in available area of suitable nesting, critical to reproduction of spiny softshell turtles, coinciding with increased abundance of nest predators indicates that the status of nesting habitat may be characterized as "depleted" relative to historical conditions.

The limited availability of nesting habitat may limit recruitment of hatchlings and increase the effect of nest predation. Concentrations of nests in small, isolated areas of nesting habitat may result in a decrease in the search time for predators and increase the predation rate on nests. Increasing the success rate of nests could increase recruitment of hatchlings.

Juvenile Habitat

Habitat suitability criteria for newly hatched and juvenile spiny softshell turtles have not been described. Hatchlings seem to prefer small shallow puddles or shallow waters on the lee shores of sandbars where water would be expected to be warmer and more protected than along exposed areas of shoreline (Plummer 1977b). This preference may be attributed to one or a combination of factors including: food availability, limited swimming ability, life-stage specific thermal preference, social interactions, cover availability and predator avoidance as Congdon et al. (1992) noted for other species of turtles. Juvenile spiny softshell turtle habitat is believed to be restricted to near shore areas of the littoral zone.

Adult Non-Winter Habitat

Many areas of littoral zone habitat along Lake Champlain as well as tributary rivers and creeks is potential habitat for non-wintering adult spiny softshell turtles. Frequent observation of turtles within certain areas of the lake indicates the presence of suitable foraging and basking sites in the immediate area. Such areas include the lake around the Missisquoi Bay Bridge, Mud Creek, Pike River, First Creek, Rudy's Creek, the north end of North Hero, Jewett Brook, Lamoille River, the Sandbar wetlands, Cranberry Pool, Missisquoi River, Dead Creek, and Charcoal Creek. Adult spiny softshell turtles were observed feeding and courting/mating in the marsh on the Sandbar Waterfowl Refuge adjacent to the Route 2 causeway during 1990 (T. Graham pers. comm.). Males have also been observed following females to the nesting beach at Sandy Point in Swanton (S. Parren pers. comm.).

Habitat conditions associated with presence of adult spiny softshell turtles include soft bottom substrate having some aquatic vegetation which turtles use for foraging and escape cover in Lake Champlain and tributary streams. Spiny softshell turtles are capable of movement at water temperatures approaching freezing. However, turtles seek refuge and become inactive when waters cool to approximately 12.8 C (55 F), typically in October (Normandeau 2005) with activity increasing again in May when waters warm. Spiny softshell turtles are very good swimmers and have been found in water to depths to at least 6.4 m (21 ft.) in Lake Champlain (Martin Léveillé pers. com.).

Spiny softshell turtles bask in the sun on fallen trees with underwater limbs, sandbars and mudflats. Individual and group basking also occurs on rocks, logs, mud flats, sand banks, and floating debris. These basking habitats are considered important (Ernst et al. 1994). Graham and Graham (1997) found partially submerged, dead tree trunks to be the preferred basking substrate in the Lamoille River.

Adult spiny softshell turtles occur in Lake Champlain to depths of > 6.4 m (20 ft.) though this is more often the case during the winter. They also are found in the littoral zone, marshes and tributary streams to Lake Champlain. Adult turtles are commonly observed basking on large wood debris, rocks, shorelines, and other objects on sunny days. They also bask on the surface in warm shallow water. It is likely that the recruitment of large wood from river systems and lake shores is significantly reduced from historical levels. This may negatively impact the availability of natural basking habitat for turtles.

Food and aquatic cover for this species is abundant in isolated areas of Lake Champlain. The entire Missisquoi Bay is in close proximity to the shoreline and associated rivers and creeks are all potential foraging areas as well as the Lamoille River and surrounding lake shallows.

Adult Winter Habitat

Hibernacula provide well oxygenated water, are free of ice scour, and lack disturbance that would cause a turtle to leave the site. Spiny softshell turtles during hibernation could be vulnerable to reduced oxygen as they live under the ice for several months with low metabolism and reduced activity. Some oxygen is able to diffuse through the soft shells of these turtles, however, lactic acid builds up in their bodies more rapidly if the dissolved oxygen level in the water is low. It is not known whether or not lactic acid build up ever results in fatalities in the wild. Jackson et al. (2000) noted that the spiny softshell turtle is less able to tolerate sustained submergence in oxygen depleted water than other species of turtles. The availability of adequate over-wintering sites is essential to softshell turtle survival, particularly at Vermont's latitude.

Most of the telemetry locations of overwintering spiny softshell turtles in Lake Champlain have been in deeper water beyond the littoral zone. No tagged turtle has been found to utilize the middle of the lake. Water depth at overwintering sites has been recorded as >2.5 m (>8.2 ft.) (Galois et al. 2002) (Fig. 3; Table 3).

However, DonnerWright et al. (1999) found a significant positive relationship between spiny softshell abundance and mean water depth and velocity in a riverine population: spiny softshell turtle were more abundant in deeper, faster water. Williams and Christiansen (1981) concluded that females preferred open water more than males. In Kansas, smooth softshell males preferred areas with emergent sandbars while females preferred deeper, more open water until nesting season when they moved to shallower water adjacent to sandbars (Plummer 1977b). Data collected in 2003 demonstrate that Lake Champlain females may prefer shallow waters post-hibernation: shortly after dispersing from their hibernacula, most of the 10 radio-tagged females were located in shallow emergent and shrub wetlands (Vanasse Hangen Bruslin, Inc and Normandeau Associates, Inc. 2004.). Along the Lamoille River, Graham and Graham (1991) commonly found males and juveniles buried at the water's edge along sandy beaches and sandbars, but not females.

The spiny softshell turtle is known to use an area in the vicinity of the Missisquoi Bay Bridge for over-wintering. The number of turtles using this site has been estimated at 124 turtles, mostly females. Other sites include an area off the Alburg shore, about 0.8 km (0.5 mi) south of the Missisquoi Bay Bridge, a site opposite Big Bluff, 2.4 km (1.5 mi) south of the Missisquoi Bay Bridge that extends well away from the shoreline, the Missisquoi River delta area, the Missisquoi River on an upstream bend, and the Lamoille River. Only one to a few turtles has been observed to occur in most of these areas. Lapan's Bay is suspected as a likely area to be used by males. No information exists concerning historical over-winter use of the Winooski River. It is known that many individual spiny softshell turtles return to the vicinity of the Missisquoi Bay Bridge each fall after spending the summer elsewhere. Built in 1938, the Missisquoi Bay Bridge includes a causeway that crosses the northeast arm of Lake Champlain and connects Swanton to Alburg.

There is no information on the historic use of this area for over-wintering by softshells prior to the construction of the bridge and its causeway in the late 1930's. However, after several years of radio-tagging and direct observation, researchers have concluded that the area surrounding the causeway is currently an important hibernaculum for softshell turtles (Lyttle 1999, Normandeau 2001, Galois et al. 2002). During the winters of 1996-99, 91% of the tagged females (n=11) and 40% of the males (n=5) over-wintered in the vicinity of the bridge (Galois et al. 2002). Radio tagging determined that at least nine females over-wintered at the causeway in two consecutive years. During the winter of 1998-99, all radio-tagged females (n=6) and 25% of radio tagged males (n=4) over-wintered at this site. All females with transmitters returned the following winter (Lyttle 1999).

At least 23 turtles, 21 PIT-tagged and two radio-tagged females, may have over-wintered at this site in 2000-2001 if all turtles captured in the vicinity of the bridge during September remained to over winter in the vicinity (Normandeau 2001). Based upon PIT-tagging and an extension of the Petersen-Lincoln estimator, the number of softshell turtles over-wintering at the causeway was estimated to be 124 (Normandeau 2001). However, this estimator is designed for closed populations and the resulting estimate may be biased if new individuals gathered at the bridge after the beginning of the capture effort (Normandeau 2001). Examination of PIT and radio tagging data between 1997 and 2004 allows calculation of a minimum count of 64 softshells in the vicinity of the causeway.

Data gathered from these studies indicate that the causeway hibernaculum is the major known concentration of over-wintering spiny softshell turtles in Lake Champlain (Normandeau 2001). The long (1.1 km or 3,608 ft) rocky causeway likely provides an abundance of food and basking sites that are useful in preparation for hibernation (Galois et al. 2002). This deep section of the Bay is similar to a riverine habitat with increased velocity of flow through the opening of the causeway and a relatively high dissolved oxygen level (Lyttle 1999, Normandeau 2001, Galois et al. 2002). The formation of ice cover around the causeway has been found to occur later in the season (January 5 versus December 6, 7, and 21 at the other hibernacula), is generally thinner, and is partly open by February and March (Normandeau 2001). It is thought that the causeway protects the turtles from ice-scour during the spring ice-sheet break-up and absorbs heat from the sun, warming the water at a faster rate than those of surrounding waters (Lyttle 1999). The causeway opening is deep, but surrounding waters are shallower. Without the causeway water depth would likely be less and more at risk to ice effects.

It is likely that no single site characteristic, but rather a combination of factors, has led to the creation of this highly favored over wintering site. The fact that some individuals travel long distances to this hibernaculum (approximately 20 km or 12.4 mi from Pike River) and are demonstrating site fidelity may indicate that the needs of these turtles are being particularly provided for at the causeway area (Normandeau 2001). The high number of turtles thought to be wintering at this site (n=124) is the strongest evidence of its importance. Biologists working on radio-tracking studies are beginning to suspect that the causeway site may also provide for important social interactions such as breeding (R. Simmons pers. comm.).

Removing the causeway and constructing a new bridge could alter the hibernacula's physical characteristics and could lead to increased human disturbance. The Vermont

Agency of Natural Resources and the Vermont Endangered Species Committee held three meetings as part of the public hearing process to gather input on an application by the Vermont Agency of Transportation to build a new bridge and remove the old Missisquoi Bay Bridge and the rock causeway. An Endangered and Threatened Species Permit was issued in January of 2002 that allowed construction of a new bridge and removal of up to 100 m (330 ft) of the western end of the eastern arm of the causeway. The following conditions were imposed within the permit:

(1) methods and technologies that minimize disturbance and/or maintain and enhance habitat will be explored;

(2) potential long-term changes to the hibernacula physical parameters such as flow, sedimentation, and dissolved oxygen will be minimized;

(3) changes in those levels are to be monitored quarterly with winter sedimentation levels not to exceed pre-construction levels and winter dissolved oxygen levels not to drop below average pre-construction levels;

(4) construction north of the causeway will be prohibited and;

(5) construction will be restricted from September 1 – April 30 (amended to October 1 – April 30) in order to reduce disturbance during the hibernation period.

A permanent basking area was constructed as part of the bridge project. This structure was built to replace basking habitat lost when the bridge was built and old barges were removed. Two temporary, floating basking platforms measuring 3.7 x 7.3 m (12 x 24 ft) were installed during bridge construction in late summer of 2002. During 2003 one platform was split into two smaller platforms and one was moved north of the causeway. Various enhancements, including slate facing and decoy turtles were installed. It was concluded that these enhancements were not necessary. Map turtles, as well as spiny softshell turtles have used the platforms, especially the one located north of the causeway near a traditional basking rock. Because the bridge construction permit conditions limited disturbances north of the causeway and turtles seemed to favor the basking platforms located north of the causeway, most of the platforms were placed north starting in 2005.

A change in the turtle over-wintering pattern occurred during the fall and winter 2004-2005. Monitoring by Normandeau (2005) found only 57% of the tagged females using the causeway hibernaculum. Some over-wintering turtles shifted use to an area north of the causeway. The most telling observation may be that two females that arrived at the causeway in the fall deserted the area and moved to the Missisquoi River and over-wintered in areas females had not been known to use during the winter. It is possible that noise or other disturbances related to construction caused some of the radio-tagged turtles to hibernate at sites outside of the main causeway hibernaculum (Normandeau 2005). This shift in over-winter sites raises questions: Are known hibernacula obligate sites for over wintering turtles? Do alternate sites have lesser habitat suitability for over-winter turtles? Does body condition, health, or reproductive condition vary depending upon habitat suitability of over-wintering sites?

Basking Habitat

Spiny softshell turtles regularly emerge from the water to bask in sunlight. As is the case with all ectotherms, achieving optimal body temperatures allows physiological processes to proceed at a faster rate. Biologists have shown that basking also provides parasite/disease prevention benefits. Although, documentation of mortality or reduction of reproductive capacity directly related to lack of suitable basking habitat or exposure to sunlight does not seem to exist for this species, it is well known that body temperatures below or above the optimum, change the rates of physiological processes and extremes can cause death.

Spiny softshell turtles are known to regularly bask: on the rocks along the Missisquoi Bay Bridge causeway, particularly the southwest portion; along the north side of the causeway near the west shore; on the old barges located at the northwest end of the causeway (now removed); at Blue Rock; and along the shoreline of the Missisquoi River, especially between Shad and Metcalf Islands. Spiny softshell turtles have also been observed basking at Cranberry Pool, Dead Creek, and Charcoal Creek. Basking by spiny softshell turtles has been observed along the Lamoille River from the Vermont Fish and Wildlife Department's fishing access downstream to the lake. They use fallen cottonwoods (*Populus deltoides*) along both banks of the north fork of the river near the mouth of the river (T. Graham pers. comm.).

Galois et al. (2002) reported 71 observations out of 671 telemetry locations made between 1996 and 1999 of basking of spiny softshell turtles in northern Lake Champlain. He reported basking occurring 56% at shoreline, 20% on tree trunks, 14% on rocks, and 10% on floating vegetation.

It is not possible from Galois et al.'s (2002) observations to determine whether choice of basking substrate could have been influenced by availability rather than preference. No historical record of spiny softshell basking locations is available. If large woody debris, for example, is more preferred than rock, there must be substantially less basking habitat available today in the lake and in rivers than there was historically. Lack of recruitment of large wood into stream channels has been identified as a common problem affecting stream habitat for fish and other riverine species in Vermont. Lack of riparian forestation or small size of riparian trees as well as the public perception that stream channels should be "cleaned" of wood have greatly reduced the amount of wood moving through river systems in Vermont. Large wood used for basking habitat by turtles may be substantially reduced in abundance in some rivers and Lake Champlain from what existed historically, but the lower reaches of the Missisquoi and Lamoille rivers still have abundant large wood.

Suitable basking substrate must be exposed to direct sunlight. Development has changed the shoreline and riparian vegetation. It is probably not possible to assess how changes in sunlight exposure combined with changes in suitable substrate have together worked to change the availability of suitable basking substrate. Given the loss of large woody debris on a large scale, it is possible that basking habitat could be in a relatively "depleted" condition compared to historical availability.

VI. THREATS AND FACTORS INFLUENCING THE POPULATION IN LAKE CHAMPLAIN

Typically, adult breeding populations of any species will increase only when the recruitment rate for that species exceeds the mortality rate and vice versa. To increase the number of breeding adults in any species, some limiting factor must be changed that results in either an increase in recruitment, decrease in mortality, or a combination of both.

Each life stage of a species has its own unique set of habitat conditions which both limit and define the suitability of areas or space as habitat. Recruitment of breeding adults can be limited by mortality within any life stage making it necessary to assess the requirements of all life stages.

Each factor potentially limiting the suitability of habitat for the various life stages of any species fall naturally within physical, chemical, or biological categories or combinations of one or more of them. Although limiting factors for any life stage or species may be expected to change through time, it is possible that just a few factors act to limit the size and distribution of any population in the short term (Bovee 1982). Recent studies show that a variety of factors that by themselves do not limit recruitment or survival can together cause mortality or lack of recruitment. Current knowledge may not allow the identification of all possible limiting factors for the spiny softshell turtle. However, a systematic process of assessment of limiting factors, corrective action, and evaluation of population response is likely to be most effective. When unexpected results occur, it may become necessary to “loop back” and assess the possibility of some unknown limiting factor.

Threats and Factors Affecting Habitat

It appears that the most limiting factor(s) affecting the spiny softshell turtle population in Lake Champlain and its tributaries is physical in nature and relate largely to the abundance, availability and quality of important habitats. Most environmental changes that can be documented to have changed spiny softshell turtle habitat are physical in nature. Construction of houses, camps and other structures on sand, gravel shorelines has diminished the amount of shoreline area having exposed sand/gravel soils suitable for nesting and incubation habitat. Construction of rip-rap and concrete retaining walls has blocked passage of turtles from the water to nesting habitat. Erosion of sand/gravel soils documented at Sandy Point in Swanton (Swanson et al. 2001) is evidence of actual loss of soils suitable as nesting and incubation habitat. The planting and growth of trees, shrubs and other shoreline vegetation has resulted in shading or sod cover at nesting sites. This has reduced the delivery of light and heat to incubation substrates or made nest excavation difficult or impossible.

Basking habitat is also essential for the survival of this species. Availability of suitable basking habitat along lake and river shorelines provides important areas for all turtles to regulate their temperature which is of particular importance in northern latitudes. It is not clear to what extent this important habitat is limiting in Lake Champlain, but it could be limited within the lake itself as a result of similar factors described above related to nesting habitat.

Water Quality Factors Affecting the Species

Although little is known of the effects that contaminants and toxins have on spiny softshell turtle, it is believed that they may be more susceptible than other turtle species because of their ability for cutaneous respiration underwater (Stone at al. 1992) and their relatively permeable carapace (Dunson 1960). Spiny softshell turtles have the highest known skin water fluxes measured for any reptilian skin. Softshell skin is more than 5 times more permeable to water than is stinkpot (*Sternotherus odoratus*) skin and nearly 18 times more permeable than mud turtle (*Kinosternon subrubrum*) skin (Dunson 1960). Carr (1952) reported that spiny softshell turtles were susceptible to the fish poison rotenone in lakes while other turtle species were not. In 1974, eggs and tissues from midland painted (*Chrysemys picta marginata*), map (*Graptemys geographica*), snapping (*Chelydra serpentine serpentine*), Blandings (*Emydoidea blandingii*), and eastern spiny softshell turtle underwent contaminant analysis in Ontario (Bishop and Gendron 1998). Among these five species, the highest contaminant concentrations were found in spiny softshell turtle eggs from Rondeau Provincial Park. Spiny softshell turtles have disappeared from the more polluted sections of rivers and lakes in the Great Lakes region (Harding 1997). There are no data to compare the amount or nature of pollution in Missisquoi Bay today as compared to the 1930's. Still, water pollutants and the presence of toxins in Lake Champlain that could impact survival of softshell turtles are of concern and merit consideration as factors potentially impacting turtle survival.

Turtle die offs have been reported from tributaries of Lake Champlain. Both Dead Creek and Otter Creek have had reported winter mass mortalities in the last ten years (VT Herp Atlas). Although neither of these were fully investigated, low dissolved oxygen as a result of decomposition of increased submergent plant growth has been shown to cause fish and turtle mortality elsewhere and may have been a factor here. In addition, the combined effect of multiple contaminents has been clearly shown to have deadly consequences on other aquatic and semiaquatic species. Consequently, toxins, contaminants and water quality generally should continue to be monitored and evaluated with respect to any future possible impacts to the species.

Much of what we know about contaminants and their effect(s) on turtles comes from studies of PCBs, organochlorine pesticides, and dioxins in turtles of Ontario and New York. Results demonstrate that individual turtles can accumulate toxins over time (Stone et al. 1980) and are capable of storing high levels of toxins in their fat without any apparent detrimental effect (Olafsson et al. 1983). Contaminants have been demonstrated to reduce egg viability and alter sexual development in other turtle species (Bishop et al. 1998, de Solla et al. 1998). Egg contaminant levels can be highly variable among clutches and appear to be a function of the females feeding location, food preferences, and metabolism rather than a function of the female's size or age (Bishop et al. 1994). Toxins are passed on to eggs and can limit egg development (Bishop et al. 1991, Bishop and Gendron 1998). De Solla et al. (2003) assessed the relationship between levels of organochlorine pesticides and PCBs in eggs and egg hatchability for each of Ontario's three softshell populations. Results demonstrated that contaminants at measured levels did not negatively affect egg hatchability. Contaminant levels were similar to those found in Lake Erie's snapping turtles in which egg viability has also not been found to be negatively affected by contaminants. Contaminant levels in Ontario's spiny softshell turtle were lower than levels detected in Lake Ontario's snapping turtles in which reduced hatching success has been attributed to organochlorines (Bishop et al. 1998).

A number of toxic substances (Table 2) have been detected in Lake Champlain at levels that exceed existing guidelines or standards (Lake Champlain Basin Program 2002). Since 1992, the Long-Term Water Quality and Biological Monitoring Project for Lake Champlain has been regularly conducting physical and chemical tests at 14 Lake stations (including Missisquoi and Mallets Bay) and 18 tributary stations (including the Pike, Missisquoi, Lamoille, and Winooski Rivers). Test results have revealed that, for many parts of the Lake, bottom sediments contain elevated levels of mercury (Vt. Dept. Env. Cons. and NY State Dept. of Env. Cons. 2001). Consumption advisories have been issued for a number of fish species due to mercury levels exceeding the Environmental Protection Agency's criteria. Crayfish (*Orconectes virilis*) have been found to accumulate mercury (Vermeer 1972). Spiny softshell turtles are carnivorous bottom feeders that eat crayfish (Ernst and Barbour 1972, Oldham et al. 1996). Because turtles have a long life span, opportunity exists for long exposure and possible bioaccumulation.

Although cyanobacteria have long been part of the Lake's ecology, it wasn't until 1999 that the first blooms were observed (Watzin et al. 2003). Cyanobacteria are phytoplankton and play an important role in the Lake's ecology as primary producers. However, some species are known to produce small amounts of intracellular toxins and release them under stressful conditions (i.e., strong water currents, heat, and senescence [Landsberg 2002]). Calm, warm, nutrient-rich waters that are conducive to excessive cyanobacteria growth or "blooms" can result in high levels of these toxins being released in a concentrated area. Blooms have occurred annually since 1999, primarily in August and September and along sheltered coves and shorelines, including areas known to be used by spiny softshell turtles at this time of year (S. Parren, pers. obser.). Potentially toxin-producing species (*Anabaena circinalis, A. flos-aquae, A. planktonica, Microsystis aeruginosa, Aphanizomenon flos-aquae*) have been documented and some have been shown to dominate blooms (Watzin et al. 2003). Many blooms do not appear hazardous to aquatic and terrestrial organisms due to variations in toxin concentration(s), bloom biomass, and an organism's sensitivity (Carmichael and Falconer 1993).

Table 2. Toxic substances of high priority and potential concern in Lake Champlain, Vermont (Lake Champlain Basin Program 2002).

High Priority[1]	Potential Concern[2]
PCB's	Ammonia
Mercury	persistent chlorinated pesticides
Arsenic	Phthalates
Cadmium	chlorinated phenols
Chromium	Chlorine
dioxins/furans	Copper
Lead	VOC's (benzene, acetone)
Nickel	pesticides (atrazine, alachlor)
PAH's	strong acids and bases
Silver	potential pollutants e.g., fluoride
Zinc	

[1] High priority indicates those substances found in sediment, water, or biota at levels above existing standards or guidelines.

[2] Potential concern indicates substances that are below standard levels but monitoring is advised.

The most common cyanobacteria toxin found in Lake Champlain are anatoxin-a, a neurotoxin, and microcystins which are liver toxins (Watzin et al. 2003). Anatoxin-a is considered highly neurotoxic and can cause death within minutes to a few hours (Carmichael and Falconer 1993). The death of two dogs in Lake Champlain during 1999 was attributed to the inadvertent consumption of high levels of anatoxin-a while drinking water from the Lake. Although few studies have determined or investigated effects that anatoxin-a has on aquatic organisms (Landsberg 2002), microcystins are a common cause of water-based toxicosis (Carmichael and Falconer 1993, Carmichael 1996). Fish mortalities have been directly linked to microcystin presence at high levels and bivalves have been shown to accumulate toxin over time (Landsberg 2002). The ability of toxins to bioaccumulate across many trophic levels has also been demonstrated (Kotak et al. 1996). Anatoxin-a and microcystins typically occur throughout Lake Champlain at low concentrations. However in 2002, waters in St. Albans and Missisquoi Bays contained concentrations of microcyctins that surpassed the World Health Organizations guideline of 1 µg/L on multiple occasions (Watzin et al. 2003).

Biologists and some members of the public are concerned that blue-green algal blooms could negatively impact spiny softshell turtles. However, the susceptibility of turtles to blue-green algae toxin is not well known (Landsberg 2002).

Biological Factors Affecting the Species

Predation

Adult spiny softshell turtles have few predators. However, otters have been shown to prey on overwintering snapping, wood, and painted turtles. Otters might prey on spiny softshells if they discovered an overwintering site. Turtle nests and newly hatched turtles are preyed upon by a number of species. The raccoon, skunk, fox and coyote are predators that prey upon turtle nests. At least two of these species occur at what may be historically high numbers. The raccoon population is greatly increased because of the agricultural practice of growing large amounts of corn. The eastern coyote is a new species which has invaded Vermont within the past 75 years. It should be noted that reduction in physical habitat suitable for nesting and incubation of eggs most certainly has resulted in concentration of turtle nests. For this reason, lack of suitable physical habitat could be enhancing the effectiveness of nest predators. Raccoons, foxes, gulls, herons, large fish, other turtles and other species may prey upon young turtles. As mentioned above, some of these predators are much more abundant than they were historically.

Nest predation and killing of turtles by humans are potential biological factors that could limit recruitment to the spiny softshell turtle population in Lake Champlain.

Disease

Nest protection, rehabilitation of wild individuals, and the confining conditions of smaller and smaller preserve areas, all require the consideration of disease and the overall health status of the population of concern (Flanagan 2000). Softshell turtles are susceptible to a large variety of parasites (*Balantidium, Cryptospridium, Toxoplasma, Eimeria, Oxyurid,…*), fungi (*Dermatophyton, Aspergillus,…*), bacteria (*Clostridium, Pseudomonas, Mysobacterium, Actinobacillus, Aeromonas,…*), and viruses (*Herpes, Reovirus, Paramyxovirus,…*) (Dr. C. Lanthier pers. comm.). None of these infectious agents are specific to softshells. Nevertheless, monitoring is important. Most disease organisms live in balance with their host and their presence does not necessarily warrant intervention. However, epidemic proportions could indicate other problems such as inbreeding, environmental stress, and pollution (Dr. C. Lanthier pers. comm.). With only two populations in Vermont, the opportunity for recolonization is limited and disease of epidemic proportions would likely lead to the extinction of softshells in Lake Champlain.

Release of turtles from the pet trade is a potential threat for spiny softshell turtles and other native turtles. Due to stress and increased exposure to disease in captivity (capture, handling, transport, inappropriate housing and feeding, crowding, and contact with other species, including turtles from other hemispheres), captive turtles that end up in the wild may infect native populations. In a recent law enforcement action, seized Blandings and spotted (*Clemmys guttata*) turtles that had been acquired out-of-state showed signs of illness and when native turtles have been used as part of permitted research they were not allowed to be released due to disease concerns (S. Parren pers. comm.).

The recent explosive growth in the legal and illegal trade in turtles within the pet trade market, resulting in part from internet sales, poses a serious emerging threat to wild turtle populations. Release of turtles that have been held in captivity is a significant potential threat to the spiny softshell turtle as well as to other native turtles. Stress and increased exposure to disease during captivity, capture, handling, transport, feeding, crowding and contact with other species greatly increases the likelihood that captive turtles will acquire and harbor diseases. Recent, major increases in the pet trade have greatly increased the transport of turtles on a world-wide basis. It is not uncommon for captive turtles to either escape or be released into the wild by pet owners. This is resulting in a dramatically increased risk of exposure of wild populations to animals that have been captive and may harbor and spread diseases capable of infecting native populations.

In a recent law enforcement action, seized Blandings and spotted (*Clemmys guttata*) turtles that had been acquired out-of-state showed signs of illness. Native turtles used as part of permitted research in Vermont have not been allowed to be released into the wild due to disease concerns (S. Parren pers. comm.). There is a similar risk that rehabilitation activities could result in introduction of disease or parasites into wild populations if proper husbandry practices are not followed. For this reason, the risks of rehabilitation may outweigh the benefits.

There are only two subpopulations of spiny softshell turtles in Lake Champlain. If one or both of these subpopulations were lost, the opportunity for recolonization with the Lake Champlain genetic stock would be extremely limited or impossible. The result could be extirpation of spiny softshell turtles in Lake Champlain if a disease vector was to be introduced. If it persisted in the environment, it could prove impossible to re-establish any population because restocked animals might be subsequently infected.

Effects of Human Disturbance

The presence of humans in areas that support turtles can result in population declines even in the absence of significant habitat alteration (Mitchell and Klemens 2000). Large-scale passive recreation (i.e., hiking and fishing) led to the decline and eventual extirpation of a wood turtle (*Clemmys insculpta*) population in Connecticut (Garber and Burger 1995). Suggested reasons for the decline included collection, road kills, and disturbance of individuals by humans and dogs. Although collection and road kills are not considered to be an imminent threat to the softshell population in Lake Champlain, the presence of humans (and probably dogs) are.

Softshells are primarily an aquatic species and are at risk from anglers and boaters. Babbitt (1936) reported that anglers sometimes hooked turtles while fishing and cut their heads off. Known present-day cases of hooking in Lake Champlain include a softshell of unknown sex in Lapan's Bay (1989), a side-hooked female in Mud Creek (1999), a female downstream of the Swanton Dam (1999), a male in Lapan's Bay (2001), and an observation of an adult female with a hook and line in the Missisquoi River near Mudgett Island (2001). Boat propeller injury and mortality is also a risk as demonstrated by a female that was found dead with deep lacerations attributed to a boat propeller in the Pike River (Galois et al. 2002).

Basking spiny softshells are highly sensitive to human disturbance; on October 15 of 2000, a basking female became nervous when approached within ~90 m (~300 ft) (S. Parren pers. obser.). When disturbed by humans, softshells will often abandon their activity, be it nesting or basking, and retreat to the safety of water. Freeman (2000) demonstrated that the presence of anglers on or near the observed nesting beaches disturbed softshells and discouraged them from going ashore. Meyer (2001) recorded 195 disturbances to basking individuals in the Missisquoi River delta region between May 25 and July 7 of 2001. Of those, 92% were from motorized and non-motorized boat traffic and approximately 40% of the time the disturbance resulted in turtles leaving a basking site. These numbers can only be expected to increase as the number of lake users increase. It is not known what long-term effect repeated disturbance has on an individual's total basking time, nesting success, or basking and nesting site fidelity. Observations of individuals in the Lake Champlain population indicate some resiliency while basking: despite the fact that individuals were repeatedly disturbed from submerged logs by passing boats, they usually returned to bask within 10-15 minutes (Graham and Graham 1997).

Direct disturbance to softshell nests is also of concern. Along Ontario's Thames River, the eggs from eight nests and the stakes from six more nests were removed by humans in 1998 (Fletcher 1998). Rope barriers and informative signs are believed to be preventing some human disturbance at Vermont nesting beaches that would otherwise occur (S. Parren pers. comm.). At a posted Vermont nesting beach in late September of 2000, a contractor was cited and fined for driving a backhoe on the beach in order to work on an adjacent landowner's property. At least one nest was impacted by the compaction of nesting substrate (M. Lyttle pers. comm.).

Hibernating softshells are also at risk of human disturbance. One example of this is the Missisquoi Bridge construction that occurred 18 m (60 ft) south of the causeway at a hibernaculum. Construction equipment and techniques required to install the new bridge, particularly 8-10 piers in the area of the hibernaculum, did appear to cause some disturbance of hibernating softshells during the three year construction period. Permitting recognized this and permission to build the bridge was granted to the Vermont Agency of Transportation based on a number of conditions including those that directly address hibernaculum concerns.

In addition, concerns expressed by Vermont's Endangered Species Committee regarding disturbance and its impacts on the physiologically important basking periods pre- and post-hibernation were addressed by requiring replacement basking sites and restricting public access to the causeway's western and eastern arms. It was learned that females moved to shallow wetlands in early May rather than basking at the causeway site in the spring. An amendment allowed pedestrian access on the eastern arm in hopes that this would reduce the likelihood of human use of the western arm, off of which a rock and concrete basking structure was built. Restrictions will occur via fencing, gating, signage, and enforcement once construction activity is complete and traffic is using the new bridge. The Vermont Agency of Natural Resources does not have clear authority to restrict access by water.

Marina development near wintering sites also poses a risk to hibernating softshells. In addition to construction impacts, increased boat traffic could disturb basking turtles during critical pre- and post-hibernation periods. Knowing the locations of wintering sites may allow us to guard against these impacts.

VII. PAST AND ONGOING RESEARCH AND MANAGEMENT

Radio-telemetry Studies

Several studies have attempted to document softshell home ranges and habitat use in Lake Champlain through the use of radio-telemetry (Table 3). The goal of these efforts has been to target high-use areas for future conservation and protection policies.

In addition to radio-telemetry, a mark-recapture effort during 2000 documented the numerical importance that the causeway plays in providing wintering habitat for softshells (Normandeau 2001). Nineteen individuals (14♀, 5♂) were captured in the causeway area and marked with PIT-tags. The causeway and the bays surrounding it were patrolled weekdays during September, and the capture record indicates a preferential use of the causeway area by softshells while basking.

Table 3. Synopsis of radio-telemetry studies of the eastern spiny softshell turtle in Lake Champlain and Ontario.

Study	Study Period[1]	Total # Tagged Individuals	Knowledge Gained
Graham and Graham 1997	Jul. 1989 – Apr. 1990	3 (2♀, 1♂)	• Seasonal activity and movements along lower Lamoille River • Identification of hibernaculum site in Lamoille River
Fletcher 1998	Jun. 1997 – Aug. 1998	2 (2♀)	• Seasonal activity and movements along Thames River, Ontario
Galois et al. 2002	May 1996 – Nov. 1999	23 (15♀, 8♂)	• Home range sizes for males and females • Seasonal movements and centers of activity for males and females • Identification of nest sites (3) • Identification of hibernaculum sites (3) and documentation of site fidelity to causeway hibernaculum
Lyttle 1999	Feb. 1999 – Nov. 1999	10 (6♀, 4♂)	• Home range sizes for males and females • Identification of basking and feeding areas within Missisquoi National Wildlife Refuge • Documentation of site fidelity to causeway hibernaculum
Normandeau 2001	Jun. 2000 – Nov. 2000	9 (9♀)	• Movement in and use of previously unstudied areas (i.e., Mud Creek, Rudy's Creek, and Lapans Bay) • Confirmation of causeway as a hibernaculum
Normandeau and VHB	Aug. 2002-	10♀	• Assess response to bridge construction

[1] Study period refers to the start and end dates of the study. The total amount of time that an individual was tracked varied due to initial dates of capture and the loss of or malfunctioning transmitters. No individual was tracked for the full duration of a study period.

State Listing as Threatened in Vermont

The spiny softshell turtle was placed upon the Vermont State Threatened List in 1987.

Trapping and Electric Fencing to Control Nest Predators

Trapping in Vermont appears to have reduced the number of softshell nests lost to predation in some years (Table 4 and 5). Trapping reduces, but does not eliminate, the number of egg predators. We believe predation would have been higher if raccoon family groups were allowed to develop a knowledge and habit of foraging at nesting beaches and if the number of predators with prior knowledge of the nesting beaches were not reduced. Predation pressure observed in 2002 demonstrates the need to continue to reduce predator numbers throughout the nesting season. A total of 76 turtle nests of several species were detected in 2002, only three of which were undisturbed by predators. Late season predation is associated with hatchling emergence from the nest and it is likely that at least some of the late season nests disturbed by predators do produce hatchlings that evade predators and emerge successfully. In 2002, late season predation occurred on 71% of all nests and 68% of softshell nests. During 2003 over 150 nests of four turtle species were dug up by predators. Most nests were predated prior to hatch in spite of a concerted trapping campaign (Table 4) and electric fencing; only two softshell nests survived until emergence when predators then dug up the nests. There was also suspicion that a gray squirrel may have been digging up turtle eggs based on photo trapping and intact eggs being found unearthed. This may have been the result of fox and not squirrel.

In 2004 a more effective combination of trapping and electric fencing surrounding all nesting areas at the Swanton site was employed by USDA APHIS Wildlife Services. Red fox appear to have be responsible for much of the predation in 2003 and many were taken in 2004 (Table 4). One adult female fox evaded trapping and continued to jump the fence. Predation continued at least into December, however, only painted turtles were thought to regularly survive in Vermont nests if not emerged by December (Parren and Rice 2004). We now know that map turtle hatchlings can also survive in their nests at some sites on Lake Champlain (S. Parren, pers. obser.).

Table 4. Total number of known predated turtle nests and trapped raccoons at softshell nesting beach in Swanton, Vermont during 1998–2004 nesting seasons (S. Parren unpubl. data).

Year	No. Predated Softshell Nests	No. Predated Nests, Other Turtle Species	No. Predated Nests, All Species	No. Raccoons Trapped	No. Skunks Trapped
1998	13	28	41	0	0
1999	13	40	53	0	0
2000	3	5	8	12	0
2001[1]	1	17	18	9	1
2002[2]	38	55	93	16	2
2003[3]	38	117	155	10	5 (+1 fox)
2004[4]	6	9	15	8	2(+14 fox)
Total	112	271	383	47	10 (+15 fox)

[1] The cool, wet 2000 nesting season resulted in unhatched nests being dug up in 2001 (not counted).

[2] Assume some successful emergence from softshell nests predated starting in late August (68%)

[3] Near total loss of nests with only 12 (2 softshell) of 155 nests being predated starting in late August through late September. 2003 predated nests can be used as an estimate of all nests.

[4] Includes nests predated up to November 7. Six additional softshell nests were predated by December 2 but would probably not have emerged.

Table 5. Total number of known predated turtle nests and trapped raccoons at North Hero, Vermont nesting beach with few known softshell nests during 1998-2004 nesting seasons (S. Parren unpubl. data).

Year	No. Predated Softshell Nests	No. Predated Nests, Other Turtle Species	No. Predated Nests, All Species	No. Raccoons Trapped
1998	0	3+	3+	0
1999	1	13	14	0
2000	0	2	2	16
2001	0	3+	3+	6
2002 [1]	0	18	18	8
2003	0	19	19	15
2004 [2]	1	5	6	22
Total	2	63+	65+	67

[1] Four adult female softshell turtles were observed swimming slowly, possibly foraging at the surface, within 20 m (66 ft) of the nesting beach 17 July, 2002. One failed softshell nest with 19 eggs was unearthed on 16 November, 2002.

[2] A total of four softshell nests were detected: 1 predated October 30, one emerged without predation, one moved in June, and one washed out by wave action.

Cage Exclosures, Beach Sweeping and Wire Mesh Ground Cover

The use of wire mesh, 12.7 X 12.7 mm (0.5 X 0.5 inch) hardware cloth or vinyl-coated wire, cages to exclude predators has been used to prevent nest predation in Vermont. Fletcher (1998) found that caging seemed to be at least partially effective in preventing raccoons from accessing softshell nests but was largely ineffective against coyotes and foxes. During the 1998 field season, Fletcher found that 38% (n=39) of caged Rondeau nests, 82% (n=17) of the caged Thames River nests, and 100% (n=38) of the caged Long Point nests hatched young. The second cage design tried proved more successful in preventing raccoons from accessing the nests. In Massachusetts, a minimum burial depth of 20.5-25.6 cm (8-10 in) was found necessary to discourage skunks and raccoons, which will stubbornly dig under cages and eat the eggs of the red-bellied turtle (T. Graham pers. comm.). At Rondeau, Thames River, and Long Point, raccoons preyed on 22, 21, and 27 nests, respectively. Biologists had not found and protected any of these nests. Protection of nests may be necessary to increase recruitment of young turtles while high numbers of predators and small area of nesting habitat exist.

During 1997 and 1998, Canadian biologists in Ontario took steps to protect softshell nests from predators by "sweeping" away signs of nesting activity with a large industrial-weight broom and marking them with a stake. This method was found to be effective: during the 1998 field season, hatching was recorded from 71% (n=21) of the swept Long Point nests and, on the Thames River, all swept nests (n=17) went undiscovered by raccoons (Fletcher 1998). The technique has been effective and in use for over a decade in Plymouth, Massachusetts on the red-bellied turtle recovery project (T. Graham pers. comm.). Fletcher (1998) reported success with this technique for softshell nests in Canada. At any important nesting site in Vermont, it is unlikely that sweeping alone will suffice due to the high numbers of nesting turtles.

Use of the sweeping technique should only be used if it is determined that predators have not learned that human activity is associated with turtle nests. The use of video surveillance as described by Freeman (2000) might provide a means of assessing the effectiveness of this technique. During 2006, wire mesh was rolled over nesting areas following the active nesting season to discourage nest predation and crushing by foot traffic.

Signage and Barriers to Control Human Disturbance

In an effort to reduce human disturbance along a stretch of the Thames River where softshell turtles were known to nest, the City of London, Ontario placed five 30 x 10 cm (12 x 4 in) signs along the trails leading to the site in the spring of 1998. This effort was deemed largely unsuccessful, however, as the signs asking people to stay away from June 15-July 15 were frequently ignored and one of the signs was torn down (Fletcher 1998). However, signage at a red-bellied turtle nesting beach in Massachusetts seemed to help (T. Graham pers. comm.). Signs and the potential use of screens that act as physical and visual barriers may deter human access and minimize disturbance of turtles.

Signs and a rope line are used to minimize human disturbance at two spiny softshell turtle nesting sites in Vermont. This effort is believed to have limited human disturbance as indicated by neighbors that reported reduced human activity and little evidence of human use at these sites (M. Lyttle pers. comm.). Video surveillance was also used at one site to monitor human activity.

State park personnel, researchers and neighbors acted as monitors and attempted to deter people that ignored the signs. When a backhoe was driven past the signs and rope line onto a nesting beach to access a neighboring property, a United States Fish and Wildlife Service biologist confronted the backhoe operator and law enforcement was called (M. Lyttle pers. comm.). The backhoe damaged a spiny softshell turtle nest that contained 18 eggs: four were infertile or dead, seven were ruptured with live young and seven where intact. As described below, signage is required to restrict public access and human disturbance to artificial basking habitat associated with the new Missisquoi Bay Bridge.

Headstarting and Captive Care

Headstarting is the raising of captive hatchling in captivity and then releasing them to the wild when they are thought to be more likely to survive. The source of eggs and or hatchlings is typically wild nests. Moll and Moll (2000) state that the objective is usually to grow hatchlings to a size at which they are less vulnerable to predators. Klemens (2000) warns that there continues to be an overemphasis on interventionist management, including captive breeding, translocations, and headstarting. He advises that headstarting is only useful if conducted in concert with a strategy that will reduce the loss of adults. Without protection of adult and older juvenile turtles, programs that protect nests and headstart hatchlings have a low probability of success (Congdon et al. 1994, Heppell et al. 1996). Meyland and Ehrenfeld (2000), when writing about marine turtles where headstarting gained popularity and media attention, point out the very low rate of return of headstarted turtles to nesting areas and caution that headstarting should be considered an experiment and not a proven conservation technique. They warn that protection of eggs and hatchlings does not compensate for unnatural losses of juveniles, subadults, and breeders.

In Vermont, the Department has utilized short and longer term headstarting of young softshell turtles if their survival in the nest was compromised. Hatchlings found in nests, but not yet ready to emerge, and eggs and embryos have been salvaged and transported for captive care. During the nest emergence period (late August-October), hatchlings are kept in captivity until connective tissue is shed and shells have unfolded and stiffened. They are released to shallow water surrounding nesting beaches that provide hiding cover. Some hatchlings, if late hatches or compromised in some way, have been kept through the winter in captive care. This is an intensive process that requires daily attention to assure that turtles are kept in a clean environment, get adequate food, and have access to basking lamp heat to boost their metabolism, which aids digestion and growth (see section in basking). Captive care techniques should continue to be examined for opportunities to enhance survival.

Public Education

Signs discussing the dangers of hooking to spiny softshell turtles have been posted at access areas on Lake Champlain. Some anglers have contacted authorities regarding hooking or releasing of hooked turtles. A turtle hooking fact sheet from Ontario concerning releasing of hooked turtles was incorporated into a Vermont brochure on spiny softshell turtles that has been distributed.

Placement of Artificial Basking Habitat

Replacement basking habitat was required as part of permitting to build the new Missisquoi Bay bridge because the new bridge will shade portions of the old causeway which was used by spiny softshell turtles for basking. The old barges used to construct the causeway are also used for basking. These were removed as part of the bridge project. This highlights the importance of replacement basking habitat. Two temporary, floating basking platforms measuring 3.7 x 7.3 m (12 x 24 ft) were installed in late summer of 2002. During 2003, one platform was split into two smaller platforms and one was moved north of the causeway. Various enhancements, including slate facing and decoy turtles were installed. Many map turtles and a few spiny softshell turtles have used the platforms, especially the one located north of the causeway near a traditional basking rock. The bridge construction permit conditions limited disturbances north of the causeway. Turtles have seemed to favor the basking platforms located north of the causeway. Most of the platforms were placed north of the causeway during 2005. These platforms were used by turtles. A permanent basking area has been constructed as part of the bridge project. This new basking area is required to be protected from disturbance through the installation of fencing and signage that educates the public about the importance of the basking habitat, and restrictions against trespass. As additional information is gathered about preferred basking areas, additional permanent basking habitat in those areas could be considered.

VIII. GOALS, OBJECTIVES AND STRATEGIES FOR RECOVERY

Successful management and conservation programs for long-lived organisms, such as turtles, must recognize that protection of all life stages is necessary. For instance, programs that protect nests and head-start hatchling turtles are only one part of a broad-based conservation program that must include conservation and protection of adult and older juvenile turtles in order to achieve a viable, self-sustaining population (Congdon et al. 1994, Heppell et al. 1996). Globally, declines in turtle populations are being attributed to low annual reproductive success, delayed sexual maturity, overexploitation, and habitat alteration and degradation (DonnerWright et al. 1999).

Goal:

The Department maintains one primary conservation goal for the eastern spiny softshell turtle in Vermont. That goal is to enhance the Lake Champlain spiny softshell turtle populations to the extent that the species may be delisted from the Vermont list of endangered and threatened species.

Objectives:

Delist from current threatened status if:

1. There is evidence that there is a minimum of 250 females of breeding age in Vermont and the Québec portion of Lake Champlain; and

2. There are at least five nesting sites with a minimum of five nests each, there is evidence that at least 200 nests are protected per year (Québec portion of Lake Champlain population to be included), and successful emergence is occurring from at least 50 nests per year (5-year average); and

3. At least 2 self-sustaining populations of softshell turtles are resident in Lake Champlain, are stable or increasing, and have critical habitat protected. (Note: habitat is considered protected if owned by a conservation organization or restricted by conservation easement and subject to management intended to maintain or enhance the species, or private lands managed for the species with a landowner agreement).

Justification:

Softshell turtles are at risk of loss in Vermont and the northeast region due to the following factors:

1. Female softshells do not attain sexual maturity until approximately 12 years of age (possibly older in the northern portion of their range) and, once sexual maturity is attained, the rate of reproductive failure is high due to the northern climate and high

rates of nest predation. Recruitment rate (i.e., the proportion of hatchling females that survive to breeding age) is low;

2. Historical nesting habitat has been lost and present-day nesting habitat is fragmented and/or degraded. Turtle nesting is concentrated at some sites and nests likely face a greater risk of predation;

3. Existing populations are vulnerable to catastrophic occurrences due to the act of nesting and hibernating "en masse". Disease outbreaks and other stochastic events, as well as pollution including a chemical spill, could potentially wipe out a population and the probability of recolonization is correlated to the number of populations that persist. With so few populations, meta-population rescue potential is reduced;

4. To date, scientists in Vermont and the region lack an adequate understanding of softshell turtle population demographics, productivity, mortality, and recruitment in Lake Champlain. Importantly, there is no knowledge regarding the extent to which immigration and emigration is occurring between the Lamoille and Missisquoi sub-populations in Lake Champlain.

Having 250 females of breeding age and an average of 200 nests annually spread over five sites would allow some protection from total nest loss each year. Depending on physiological condition, weather, and water levels, not all females may nest each year. However, the total number of breeding females in Lake Champlain will be based on the total number of nests located in a given nesting season. Even with management, nests are vulnerable to predation and other losses, especially when nests are concentrated. By having at least 200 nests receiving some protection over five sites, we believe sustained recruitment will occur (i.e., the population will maintain or increase itself).

We have one estimate of 60 turtles for the Lamoille River subpopulation (Graham and Graham 1997) and an estimate of adults and older juveniles using the Missisquoi Bay causeway area during winter of 124 individuals (Normandeau 2001). It is likely that the Missisquoi Bay subpopulation totals at least 200 based on information that most large females use the causeway and that, while some males use the causeway area, others are able to utilize additional areas during the winter. By the spring of 2003, 19 of 22 (86%) tagged female softshells used the Missisquoi Bay causeway as a wintering site. The ratio of males to females at the causeway area in the fall is about 1:4, so the estimate of 124 total turtles using the area could represent 93 females and 31 males. If the estimated 93 females at the bridge during the winter make up 86 of all Missisquoi Bay females, the total number of females using the Bay may be 108. These numbers are uncertain and indices of population change may need to be employed.

The minimum effective population size to sustain a population over the long term is sometimes estimated to be 500 adults (Frankel and Soule 1981). While 500 breeders, or 250 potential nesters (assuming a 1:1 sex ratio) is desirable, we believe a target of 200 nests is more reasonable given the current situation and the longevity of the softshell turtle.

The Department believes that the goal and objectives presented in this plan are compatible with Canada's spiny softshell turtle action plan as described in brief below:

Action Plan for the Eastern Spiny Softshell in Canada:

Goal: Down-list the eastern spiny softshell turtle population from 'threatened' to 'vulnerable' in Canada.

Objectives:

1. Prevent any declines in current population numbers.
2. Manage habitat in order to allow for the population to increase itself.
3. Prevent any net loss of habitat for the southwestern Ontario subpopulation.
4. Increase the amount of habitat available for the other subpopulations.

To be successful, it is essential that all partners in Vermont and Québec work cooperatively to recover the eastern spiny softshell turtle population in Lake Champlain. An informed and supportive public will enhance recovery of the species.

Recommended Actions for Recovery:

The following actions are recommended and encouraged to ensure the long-term viability of Lake Champlain's spiny softshell turtle population.

Management

1. Protect known habitats from disturbance.

The following areas are currently known, suspected (s), or have historical evidence (h) of use. Priority is given to these habitat types in the following order: nesting, wintering, basking, and foraging habitat.

Nesting: Pike River, Providence Point, West Swanton, Camp Kiniya , Big Bluff (s), north end of North Hero, Bullrush Point (s), Lapan's Bay, Lamoille River, Clay Point (h), Winooski River (h).

Wintering: Missisquoi Bay Bridge causeway area (estimate of 124 turtles, mostly females); Alburg shore, about 0.8 km (0.5 mi) south of causeway (one radio-tagged female); opposite Big Bluff, 2.4 km (1.5 mi) south of the causeway and well away from the shoreline (one radio-tagged female); Missisquoi River delta (three radio-tagged males); Missisquoi River upstream bend (one radio-tagged female); Lamoille River (several females with map turtles); Lapan's Bay (s); and St. Albans Bay (s). We have no information on the wintering habitat for the historical Winooski River population.

Basking: Missisquoi Bay Bridge causeway, particularly southwest portion (new span bridge does shade this area and replacement basking was a permit condition); rock north of causeway near west shore; old barges at northwest end of causeway (were removed); Blue Rock; and Missisquoi River, particularly between Shad and Metcalf Islands. Softshell turtles have also been observed basking at Cranberry Pool, Dead Creek, and Charcoal Creek. Basking by softshells on the Lamoille River has only been noted from the public access down to the lake. In particular, softshells use fallen cottonwoods (*Populus deltoides*) along both banks of the north fork of the river near its mouth (T. Graham pers. comm.).

Foraging: The entire Missisquoi Bay in close proximity to the shoreline and associated rivers and creeks are all potential foraging areas as well as the Lamoille River and surrounding lake shallows. Specific foraging areas include Missisquoi Bay Bridge causeway area, Mud Creek, First Creek, Rudy's Creek, north end of North Hero, Jewett Brook, Sandbar wetlands, Cranberry Pool, Dead Creek, and Charcoal Creek. Softshells were observed feeding and courting/mating in the waterfowl refuge (marsh) adjacent to the Sandbar causeway in 1990 (T. Graham pers. comm.). Males have also been observed following females to a nesting beach in Swanton, not far from the Missisquoi Bay bridge (S. Parren pers. comm.).

Research and monitoring efforts have identified the habitats of particular value to Lake Champlain softshell subpopulations listed above. These habitats should be protected from the aforementioned threats in an effort to provide the turtles the energetic advantage of basking and nesting without being disturbed and lessen injury and mortality from boat strikes and hooking. Enhancement of currently known habitats, restoration of historically used habitats (e.g., Winooski River delta), or possibly creation of new habitat (e.g., nesting sites) should all be considered. Landowners of a few privately owned parcels have been contacted, but we do not currently have agreements for protection of these sites.

To implement habitat protection, the following actions will be taken:

1.1 Protect nesting beaches from human disturbance during nesting season using, when appropriate, on and offshore signage, law enforcement, and, visual screens.

1.2 Recruit local volunteers for the purpose of monitoring nesting beaches and increasing the general public's awareness of Lake Champlain spiny softshells.

1.3 Protect high-use basking areas from human disturbance via on and offshore signage and law enforcement.

1.4 Identify areas that provide critical foraging habitat, particularly for juveniles, and protect vulnerable areas from human disturbance via on and offshore signage and law enforcement if the areas are reasonably small and identifiable.

1.5 Monitor hibernacula when softshells have congregated (September – May) to ensure disturbance is minimal.

1.6 Inform state biologists of potential threats to hibernacula (e.g., potential marina development) and take appropriate actions when a hibernaculum's physical characteristics and/or hibernating individuals are threatened.

1.7 Continue to work with the Winooski Valley Park District to protect turtle nesting habitat at the mouth of the Winooski River and consider protection actions for other potential sites associated with the Winooski River.

Signage is a significant part of protection from human disturbance. However, we are cognizant of the fact that signage has the potential of increasing disturbance by attracting curious individuals, especially when signage is not backed up by a human presence reinforcing the sign's message. Activity levels should be monitored in an effort to determine whether this is occurring.

Each of these actions depends on strong commitment and communication between government agencies, private and public landowners, and the residents and nonresidents that recreate in those areas deemed critical to the softshell. For example, law enforcement is an important component of softshell habitat protection and communication links between biologists and state game wardens are critical to the success of this management tactic. Communicating with the general public in an effort to increase softshell conservation awareness is vital as the most significant threats to softshells (e.g., habitat loss, habitat degradation, and disturbance while nesting, basking, and hibernating) are human induced. These threats can only be minimized and/or eliminated by convincing the public that resides and/or recreates on Lake Champlain of the importance of softshell conservation.

2. Explore and implement legal protection that allows formal designation and protection of critical habitat against human disturbance over both land and water.

2.1 The Agency of Natural Resources/Department of Fish and Wildlife should explore and implement additional opportunities for legal authority to and perhaps work cooperatively with the Vermont Natural Resources Board, Water Resources Panel for establishing protection zones over water such as a perimeter around an important basking site or nesting beach that is legally enforceable. Current signage surrounding areas such as loon nests are really informational and law enforcement must prove harassment. Another option might be to restrict angling in proximity to areas important for listed species and vulnerable to disturbance.

3. Protect, restore, enhance, and create nesting habitat.

High quality nesting habitat is important for maintaining Lake Champlain's softshell populations. Today, the amount of available nesting habitat is believed to be significantly lower than historical amounts due to shoreline development and alteration (see Section IV - Habitat Loss and Degradation). Habitats that have not been developed or altered are probably a mix of historically high and low quality habitats. High quality nesting habitats are characterized by open sand or gravel deposits that are generally free of vegetation, have adequate solar exposure, and have relatively dry conditions throughout the nesting and incubation periods. Low quality habitats may be comprised of rocky substrates and/or encroaching vegetation that scouring spring floods fail to remove or may be subject to flooding during the nesting and/or incubation periods. Some nesting sites can be enhanced and rehabilitated, effectively increasing the total amount of area available to softshells for nesting.

3.1 Identify and rehabilitate nesting beaches where rocky and vegetative debris are reducing the quality and/or number of nesting sites. Remove debris and large rocks, providing sand-shale substrate, trimming or removing shading brush, and digging out encroaching vegetation in old shale deposits.

3.2 Select appropriate sites to create suitable substate and conditions conducive for nesting.

4. Protect and create basking habitat.

Basking habitat is important for this northern population of softshells, especially pre- and post-hibernation. Softshells prefer to bask as close to the water as possible and the availability of basking habitat in, or directly adjacent to, water that is disturbance free may be limiting to softshells. The following steps should be taken to enhance softshell basking habitat in Lake Champlain:

4.1 Maintain natural basking sites such as fallen trees if they do not pose a threat to boaters. When feasible, enhance basking areas via natural (e.g., tree limbs and trunks) structures in an effort to increase basking surface area.

4**.2** **Create** basking habitat via floating platforms or permanent structures.

5. Enhance nesting success.

In order to attain the objective of 250 breeding age females in Lake Champlain softshell populations and 200 nests, we will need to increase nest success rates. Nest success has been reduced due to high levels of mammalian predation. Activities that could attract nest predators and/or people should be avoided. The following actions would increase the percentage of nests that successfully produce young and contribute to population recruitment:

5.1 Nesting beaches could be "swept" during the nesting season in an effort to erase signs of nesting activity and reduce the number of depredated nests.

Continued use of the sweeping technique would only occur if it is determined that predators are not clueing in on such sign and this level of human activity is not negatively influencing turtle use of nesting beaches. The technique has been effective and in use for over a decade in Plymouth, Massachusetts on the red-bellied turtle recovery project (T. Graham pers. comm.). Fletcher (1998) reported success with this technique for softshell nests in Canada. At an important cobble nesting site in Vermont, it is unlikely that sweeping alone will suffice due to the high numbers of nesting turtles. The use of video surveillance as described by Freeman (2000) might provide a means of assessment.

5.2 When feasible, nests will be protected with wire blankets installed post nesting and/or with ½" x ½" hardware cloth or vinyl-coated wire mesh cages by state and federal biologists in an effort to reduce the number of depredated nests.

5.3 Mammalian predator trapping programs will be employed at nesting beaches that exhibit a relatively high concentration of nests in an effort to reduce the number of predated nests.

5.4 Tracking boards and camera sets could be used to determine what predatory species are using a nesting site, although direct monitoring has been found to be more useful so far. We will explore the use of other deterrents such as fencing (chain link/floppy), electric wire, discouraging winter denning near nesting sites, night shooting, and night patrols with a trained dog.

5.5 Consider head-starting young if their survival in the nest is compromised.

5.6 Monitor nest predation (including parasitic flies) and nesting success, excavate nest contents found due to emergence holes or predation, salvage hatchlings, embryos, and unhatched eggs and provide captive care until release is possible.

6. Pursue acquisition of those areas of habitat identified as important for maintaining and enhancing spiny softshell turtles.

Given the past and on-going impacts of development activities, acquisition or protection of critical areas of habitat will likely be an effective means towards recovery and maintaining a healthy spiny softshell turtle population. Identification of critical habitat is essential for success and cost effectiveness.

Nesting and incubation and other critical habitat should be considered for acquisition or protection. Lapan's Bay and wetlands associated with St. Albans Bay provide habitat for some spiny softshell turtles and protection and enhancement of these areas should be considered. Important privately owned habitat is also located near the Sandbar Wildlife Management Area.

Steps have been taken by organizations in both Québec and Vermont to acquire important spiny softshell turtle habitat. Québec has acquired property along the lower part of Pike River and on Missisquoi and Chapman Bays. Several important areas are in public ownership in Vermont: Missisquoi River Delta and the associated area of Missisquoi National Wildlife Refuge; Lamoille River delta system that is partially protected by Sandbar Wildlife Management Area; and two nesting beaches are in public ownership and are actively managed. Areas have already been targeted for potential acquisition, and there is a need to continue to identify important areas. In a few cases along Missisquoi Bay there may be opportunities for partners in Québec and Vermont to cooperate on land protection projects.

Research

Research associated with this plan is directed by way of an adaptive, applied management philosophy. Therefore, priority will be given to those research projects that can best inform actions for effective recovery of this species.

1. Continue to identify locations of breeding, nesting, basking, foraging and over-wintering habitat and assess habitat quality and use.

Knowledge of where softshell turtles nest, bask, and overwinter is important to the long-term conservation of this species in Lake Champlain. Several of Lake Champlain's nesting areas are known, but the potential to discover other nesting areas via radio-tagged individuals and surveillance of potential sites is worth pursuing. Knowledge of previously undocumented nesting, basking, and overwintering sites would allow for their management and protection. Habitat characteristics could be quantified and used to identify additional potential and/or probable habitat that is in need of management and protection. The following actions should be taken to increase our knowledge of softshell nesting, basking and wintering habitat in Lake Champlain:

1.1 Continue to conduct studies that monitor individuals via radio-tagging in an effort to document habitat utilization and movements between those habitats among seasons and years.

1.2 Conduct habitat surveys and assessments that provide useful information about distribution, quality, and level of disturbance by humans.

1.3 During the nesting season, consider recruiting volunteers to monitor potential nesting sites in an effort to identify previously undocumented nesting sites.

1.4 A softshell turtle reporting program that encourages the public to document softshell sightings should be part of the overall public outreach effort for this species.

1.5

Strong communication links between the general public and wildlife managers have the potential to increase our knowledge of softshell productivity and mortality. People that live and recreate near softshell habitat interact with softshells at some level, be it split-second observations or hooking one on a line. We hope to develop a stronger communication link between non-biologists and biologists in an effort to capture that information and incorporate it into the species management.

2. Monitor population demographics.

Population demographics, recruitment, mortality and growth of spiny softshell turtles are all poorly understood in Lake Champlain. The extent to which immigration and emigration are occurring between the Lamoille and Missisquoi subpopulations is also unknown. There is a need to monitor the annual number of nests occurring and to determine the proportion of successful nests and number of hatchlings produced. Radio and other tags, genetic samples and direct and indirect observation will be necessary to monitor movements of turtles and determine recruitment.

2.1 Nest success will be documented by monitoring nests and calculating the proportion of nests that successfully hatch young by the end of the nesting season.

2.2 Emergence estimates will be based on the number of hatchlings produced from each nest, through either direct observation or the counting of eggshell fragments.

2.3 All individuals captured for research should be measured, age estimated, sexed, and possibly marked via pit tags which would provide long-term information. This would aid in determining the number of breeding females and estimating the population's age structure and recruitment level.

2.4 All recovered dead specimens will be measured, age estimated, sexed, and the cause of death determined. If the cause is unclear, that individual should be necropsied .

2.5 Movements of radio-tagged individuals will aid in our understanding of the extent of interchange between populations.

2.6. Document that recruitment of young into the breeding population is occurring.

This action directly supports the objective of self-sustaining populations, but it may be difficult to provide evidence of recruitment into the breeding populations without long-term mark and recapture study. The proportion of younger (smaller) females compared to all adult female turtles may allow an inference about recruitment at a given point in time.

2.7 Consider the use of genetic methods for investigating population demographics.

Indices of population change could be employed for population parameters that are not easily measured. For example, increased observations of softshell turtles in areas with few or no current records, or decreased detections in those areas where softshells are currently and frequently observed, may inform us of population change over time. Surveys over time will likely be necessary to detect changes in populations: use of pit and radio tags would allow for new and updated estimates of populations and mortality data may provide useful information for making inferences about populations.

2.8 Investigate if Lake Champlain softshells are genetically distinct.

The United States Fish and Wildlife Service (USFWS) has been queried about the possibility of Lake Champlain's population of softshells being distinct and, hence, possibly qualifying as a federally listed species (S. Parren pers. comm.). Weisrock and Janzen (2000) obtained multiple haplotypes within the Lake Champlain population of softshells, suggesting a novel genetic variation. Analyses of *Apalone spinifera* and *A. mutica* raise the unexpected possibility that the rates of molecular evolution in these species are significantly faster than those observed in most other turtle species (Weisrock and Janzen 2000). Some tissue samples have been collected from the Lake Champlain population (P. Galois pers. comm.) but more research is necessary within and among populations to test this hypothesis.

It is important to understand the genetic makeup of Lake Champlain's softshells: if the population declines or its structure is found to be heavily skewed (i.e., few juveniles or few breeding adults), we might want to consider supplementing the population with individuals from other populations. Supplementation might also be considered if it is determined that little to no genetic exchange is occurring and individuals are demonstrating signs of low genetic diversity (i.e., inbreeding). However, if Lake Champlain's softshells are genetically distinct, supplementation could lead to a loss of that distinction and possibly adaptations to our area. To achieve a reasonable level of understanding of population genetics, tissue samples should be collected and shared with researchers examining the genetics of this species from other regions and populations. Nest monitoring and excavation of contents has proven to be an important source of tissue for genetic study.

3. Monitor for disease, parasites and environmental contaminants.

It is important to monitor opportunistically the health status of softshells, the objective being to establish reference data for this particular population's health status. When individuals are handled, their general body condition should be qualified: weight should be measured, abnormal secretions in the upper respiratory tract should be noted and cultured, and fecal samples for parasitology and bacteriology culture should be collected. Dead specimens should be submitted for a full necropsy that includes assessments of virology and toxicology (Dr. C. Lanthier, pers. comm.). No disease has ever been eradicated from a wild animal population because of the challenge of treating free-ranging animals. It is unlikely that any disease causing a pandemic among spiny softshell turtles could be controlled or eradicated. This emphasizes the importance of measures aimed at prevention of infection.

4. Determine feasibility of a Winooski River soft-shell turtle population restoration.

During the mid-1800s, softshells were present at the mouth of the Winooski River and several specimens were collected including a female carrying 29 eggs (Thompson 1853). By 1936, Babbitt (1936) considered softshells to be rare in Lake Champlain and partially attributed this to pollution from cities near the mouth of the Winooski River. At present, there are two populations (or subpopulations) in Lake Champlain: one in the Lamoille River and a larger one in Missisquoi Bay that utilizes several rivers and creeks. From the perspective of metapopulation dynamics, Lake Champlain softshells will have a much higher probability of persisting over time if present in several populations. Disease outbreaks, pollution, and other stochastic events could potentially wipe out a population and the probability of recolonization is correlated to the number of populations that persist.

4.1 The feasibility of restoring the Winooski River population remains to be determined. A full assessment of the area would have to be undertaken that includes nest site availability, proximity of potential hibernaculum, levels of human disturbance, and pollution levels. Sandy nesting substrate remains at Delta Park and along the shoreline south of the Winooski River mouth, but the Burlington-Colchester area has a relatively dense human population and human disturbance poses a serious challenge to turtle restoration. We have no recent observations of softshells in the Winooski River, although other turtle species are known to nest at Delta Park, which is managed by the Winooski Valley Park District. Park staff are very interested in and protective of turtles nesting at Delta Park.

5. Collaborate with other American and Canadian investigators, organizations, and agencies.

Collaboration on softshell turtle studies have involved various organizations including the Société d'Histoire Naturelle de la Vallée du St-Laurent; Société de la faune et des parcs du Québec; US Fish & Wildlife Service, Lake Champlain Office; Vermont Fish and Wildlife Department, Vermont Agency of Transportation and its contractors (VHB and Normandeau Associate,s and more recently McFarland Johnson).

<u>Public Outreach and Education</u>

Through the use of partnerships and outreach professionals, conduct an education and outreach effort among targeted audiences that fosters appreciation and respect for the spiny softshell turtle and an understanding of what Lake Champlain softshells need in order to remain a part of our native fauna. Targeted audiences include but are not limited to the following: internal publics (i.e., biologists and law enforcement involved with land-use reviews); the general public; boaters and anglers including license agents, marina and boat dealers, fishing derby organizers, and State parks and camping areas; landowners of critical habitat; and the news media as a means to inform the general public.

1. Incorporate Department law enforcement personnel in recovery efforts:

1.1 Develop and maintain internal communications with law enforcement and biologists to build awareness and support for turtle protection.

1.2 Incorporate softshells into existing Vermont Agency of Natural Resources fish and wildlife publications (i.e., law digest and fishing guide).

Law enforcement is critical to the protection of softshells; the general public needs to know that harassment is illegal and will be enforced.

2. Provide information to recreationists (anglers, boaters, beach-goers) on the impacts their activities may have on spiny soft-shell turtles and ways to minimize them:

2.1 Develop and place signage along important habitat areas.

2.2 Develop and place brochures at fishing license agents, marinas, fishing derbies, and State parks and camping areas.

Some work is being undertaken by Conservation de la Nature Canada (Nature Conservancy of Canada). The Vermont Fish & Wildlife Department has produced a brochure featuring spiny softshell turtle conservation.

2.3 Organize workshops at boat-ramps to educate anglers on turtle identification and fishing hook removal.

3. Develop a landowner outreach and incentives program that promotes the maintenance and restoration of natural shorelines:

3.1 Develop and distribute letters to landowners of current and potential riverine and lakeside softshell habitat.

Letters may be periodical and serve as either a reminder of the importance of softshell conservation and habitat restoration and maintenance (pre-nesting season) or inform on nesting success and recent softshell conservation efforts (post-nesting season).

3.2 Encourage softshell habitat landowners to become monitors and land stewards of that habitat for the purpose of softshell conservation.

This may involve providing brooms to sweep and protect nest sites, Ziploc bags for eggshell collection, and incentives for surveillance.

3.3 Develop an incentives program for diary farmers to halt the access and trampling of sandy shorelines by cows (i.e., provide farmers with large water tanks and electric fencing).

3.4 Provide landowners with signage that can be put on shore or in front of their house i.e., “Here we protect endangered wildlife. We help the spiny softshell turtle”.

4. Create awareness and support for protecting critical habitats by building a network of volunteers:

4.1 Institute an ongoing campaign for softshell volunteers and recruit through such avenues as the Lake Champlain Basin Program, the ECHO Leahy Center for Lake Champlain, Audubon Vermont, Friends of Missisquoi Bat, St. Albans Watershed Association, the Nongame and Natural Heritage Program’s newsletter, Vermont Paddlers Association, Kayaking Clubs, conservation commissions, high school biology students, and residents of towns containing softshell habitat.

4.2 Develop a mechanism (short form printed from the internet, pre-printed reporting-cards, phone number…?) by which softshell sightings and/or harassment can be reported to Vermont’s Nongame and Natural Heritage Program.

4.3 Institute an annual spring and/or fall “work day” on which volunteers work to rake and clear debris from known and potential softshell nesting habitat.

5. Design, develop, and distribute educational materials to the general public:

5.1 Develop slide shows, fact sheets, activity boxes, and posters to show to and distribute at towns, schools and events sponsored by the Vermont Fish and Wildlife Department.

5.2 Create interpretive displays to be placed at the ECHO Leahy Center for Lake Champlain, Missisquoi National Wildlife Refuge, Ed Weed Fish Culture Station, Lake Champlain Basin Building, and Winooski Valley Park District.

6. Develop a media campaign:

6.1 Develop and maintain a storyboard of press release ideas.

6.2 Write press releases from the developed storyboard ideas and distribute to Vermont news media.

6.3 Work directly with media professionals.

7. Develop a webpage link from the Department’s website that provides information about spiny soft-shell turtles, related conservation efforts, how to acquire educational materials, and updates on research.

Partnerships

Partnerships with other organizations will assist in the recovery of Lake Champlain's softshell population and opportunities for collaboration should be pursued.

Existing partners include:

- Audubon Vermont
- ECHO Leahy Center for Lake Champlain
- Conservation de la Nature Canada (a.k.a. The Nature Conservancy of Canada).
- Lake Champlain Land Trust
- Missisquoi National Wildlife Refuge
- Société d'Histoire Naturelle de la Vallée du St-Laurent
- Société de la faune et des parcs du Québec
- The Nature Conservancy, Vermont Field Office
- United States Department of Agriculture, Wildlife Services
- United States Fish & Wildlife Service, Lake Champlain Office
- Vermont Department of Fish and Wildlife
- Vermont Department of Forests, Parks, and Recreation
- Vermont Endangered Species Committee
- Vermont Scientific Advisory Group on Reptiles and Amphibians
- Friends of Misssiquoi Bay
- St. Albans Watershed Association

1. Work with others to identify and protect important habitat areas.

Steps have been taken by organizations in both Québec and Vermont to acquire important softshell habitat. Quebéc has acquired habitat at the mouth of Pike River and several important areas are already in public ownership in Vermont: Missisquoi River Delta and the associated area of Missisiquoi National Wildlife Refuge; Lamoille River delta system that is partially protected by Sandbar Wildlife Management Area; and two nesting beaches in public ownership and actively managed. Some areas are already targeted for potential acquisition and we should continue to identify other important areas. In a few cases along Missisquoi Bay there may be opportunities for partners in Quebéc and Vermont to cooperate on land protection projects.

2. Work cooperatively to study and manage the spiny softshell turtle in Lake Champlain.

The strength of the softshell turtle research and management has been the involvement of many organizations and international cooperation. We should continue along this shared path to recover the softshell turtle in Lake Champlain.

<u>Fundraising</u>

Explore future funding opportunities such as:

- Conservation and Reinvestment Act (CARA) legislation
- Lake Champlain Management funds
- Lintilhac Foundation
- Lake Champlain Basin Program
- Landowner Incentive Program

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