Species Status Assessment

Class: **Bivalvia**
Family: **Unionidae**
Scientific Name: ***Lampsilis cariosa***
Common Name: **Yellow lampmussel**

Species synopsis:

Lampsilis cariosa belongs to the subfamily Ambleminae and the tribe Lampsilini, which includes 17 extant and 6 likely extirpated New York species of the genera Actinonaias, Epioblasma, Lampsilis, Leptodea, Ligumia, Obovaria, Potamilus, Ptychobranchus, Toxolasma, Truncilla, and Villosa (Haag 2012; Graf and Cummings 2011). *L. cariosa* is one of seven species of the genus Lampsilis that have been found in New York (Strayer and Jirka 1997).

Since 1970, *L. cariosa* has been found in 25 New York waterbodies. *L. cariosa* occurs in small to large rivers, especially in riffles (Ortmann 1919, Strayer 1993), and is often fairly abundant where it occurs (Strayer & Jirka 1997). This species has declined between 30% and 50% in both the short and long term (NatureServe 2013). It is declining everywhere along its range, which includes most of the Atlantic coast, from Georgia to Nova Scotia.

In New York, *L. cariosa* is ranked as vulnerable, and as vulnerable/apparently secure throughout its range (NatureServe 2013). In North America, approximately 2/3 to ¾ of native mussel species are extinct, listed as endangered or threatened, or are in need of conservation status (Williams *et al.* 1993; Stein *et al*., 2000). While population trends in New York are unknown, it is assumed that they too are declining, due to a myriad of environmental stressors.

Status

a. Current and Legal Protected Status

i. **Federal** ____ ___ None ____________________________ **Candidate?** ___No______

ii. **New York** _____Species of Greatest Conservation Need___________________

b. Natural Heritage Program Rank

i. **Global** ___G3G4 – Vulnerable / Apparently secure ________________

ii. **New York** _____S3 - Vulnerable_______ **Tracked by NYNHP?** ___Yes_______

Other Rank:

Canadian Species at Risk Act (SARA) Schedule 1/Annexe 1 Status: SC (2005)
Committee on the Status of Endangered Wildlife in Canada (COSEWIC): Special Concern (2004).
IUCN Red List Category: Endangered
American Fisheries Society Status: Threatened (1993)
Species of Regional Northeast Conservation Concern (Therres 1999)

Status Discussion:

Range, though widespread geographically, has contracted significantly with local extirpations and abundance in decline nearly everywhere except a few exceptional sites in New York and Maine. Area of occupancy has declined even more than range extent, as most occurrences are represented by small populations having poor viability with few individuals (NatureServe 2013).

II. Abundance and Distribution Trends

a. North America

i. Abundance

__X__ declining ____increasing _____stable ____unknown

ii. Distribution:

__X___ declining ____increasing _____stable ____unknown

Time frame considered: ____Short and long term________________________

b. Regional

i. Abundance

__X__ declining ____increasing ____stable _____unknown

ii. Distribution:

__X__ declining ____increasing ____stable ______unknown

Regional Unit Considered:_______Northeast_______________________________
Time Frame Considered: ____

c. Adjacent States and Provinces

CONNECTICUT Not Present _______ No data _______

i. Abundance

____ declining ____increasing ____stable __X__unknown

ii. Distribution:

____ declining ____increasing ____stable __X__unknown

Time frame considered: ____
Listing Status: __Special Concern (extirpated), Endangered____ SGCN? ________

MASSACHUSETTS Not Present _______ No data _______

i. Abundance

__X__ declining ____increasing ____stable ____unknown

ii. Distribution:

__X__ declining ____increasing ____stable ____unknown

Time frame considered: ____
Listing Status: ____SH – Historic, Endangered_______________ SGCN? __Yes____

NEW JERSEY **Not Present** _______ **No data** _______

i. **Abundance**

____ **declining** ____**increasing** ____**stable** __X__**unknown**

ii. **Distribution:**

____ **declining** ____**increasing** ____**stable** __X__**unknown**

Time frame considered: ________1970-present________________________________
Listing Status: __S2 -Threatened______________________ SGCN? __Yes________

In New Jersey, the yellow lampmussel is restricted to the Delaware River. Although it appears to be doing well in occupied stretches, impacts to water quality, along with proposed instream projects, threaten existing populations. Sea level rise, salt water intrusion, and extreme weather events all pose long term threats. Jeanette Bowers-Altman (2013 personal communication) states that "although I have chosen abundance and distribution as unknown, gut feeling is that both are relatively stable in the river for now." All eggs are in one basket here, making this population especially vulnerable to threats (Davenport 2012).

ONTARIO **Not Present** __X____ **No data** _______

PENNSYLVANIA **Not Present** _________ **No data** _______

i. **Abundance**

____ **declining** ____**increasing** __X__**stable** ____**unknown**

ii. **Distribution:**

____ **declining** ____**increasing** __X__**stable** ____**unknown**

Time frame considered: ____
Listing Status: ___S3S4____________________________________ SGCN? ____Yes____

QUEBEC **Not Present** ____X___ **No data** _______

VERMONT **Not Present** __X____ **No data** ________

d. NEW YORK **No data _______**

i. Abundance

__X__ declining ____increasing ____stable _____unknown

ii. Distribution:

__X__ declining ____increasing ____stable ______unknown

Time frame considered: ____

Monitoring in New York.

As part of a State Wildlife Grant, NYSDEC Region 8 Fisheries and Wildlife staff is conducting a baseline survey of tributaries in central and western NY for native freshwater mussels 2009 – 2017.

Trends Discussion:

Trends for New York populations are difficult to determine as most historic data comes from opportunistic naturalist collections, as opposed to more comprehensive baseline surveys. For example, mussels were documented for the first time in 50 of the 106 streams surveyed to date by the Southern Lake Ontario mussel inventory project (Mahar & Landry, 2013). This is because many of these streams had never before been surveyed for mussels, not because mussel distribution has dramatically increased. In North America, approximately 2/3 to ¾ of native mussel species are extinct, listed as endangered or threatened, or are in need of conservation status (Williams *et al.* 1993; Stein *et al.*2000). Based on New York's Natural Heritage S-rank, sparse historical data, and the plight of North America's freshwater mussels, it is assumed that trends are declining due to a myriad of environmental stressors.

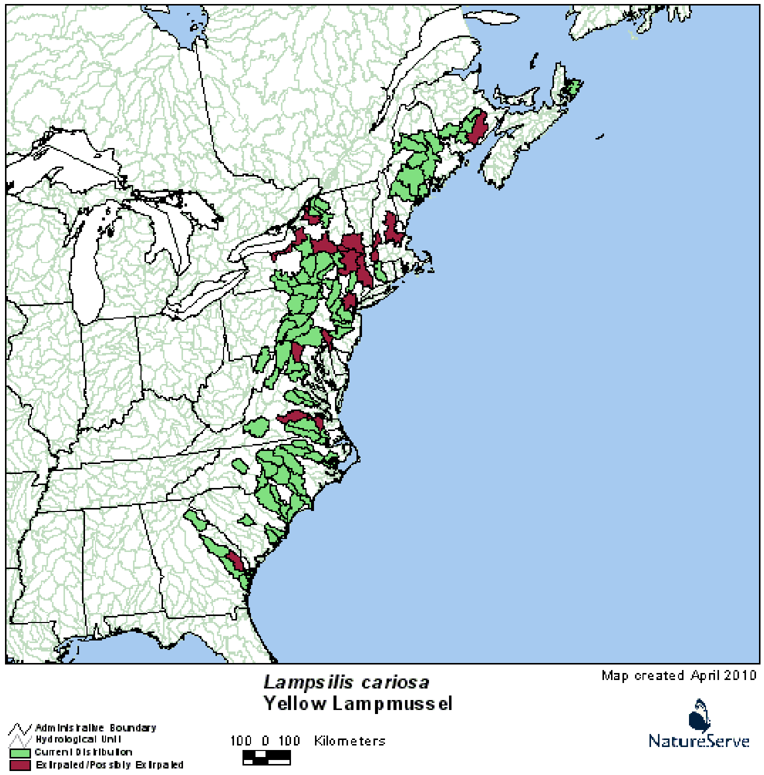

Figure 1. *L. cariosa* distribution in North America (NatureServe 2013).

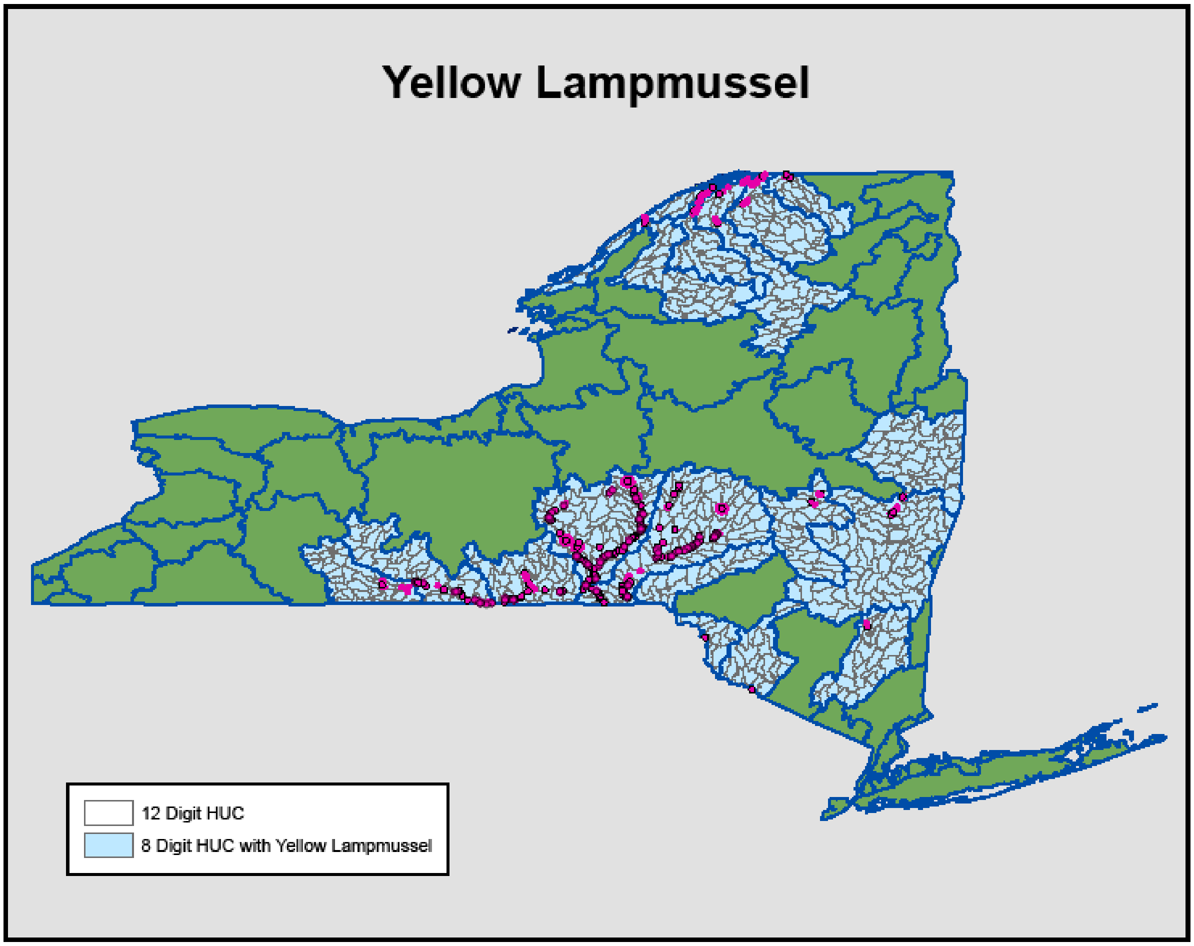

Figure 2. Post 1970 *L. cariosa* distribution in New York State (Mahar & Landry 2013; Harman & Lord 2010; The Nature Conservancy 2009; New York Natural Heritage Program 2013; White et al. 2011).

III. New York Rarity, if known:

Historic	# of Animals	# of Occurrences	% of State
prior to 1970	unknown__	_~19 waterbodies_	~17 of 56 HUC 8 watersheds
prior to 1980	________	________	________
prior to 1990	________	________	________

Details of historic occurrence:

In New York, there are many *L. cariosa* records from the Susquehanna and Hudson basins. For several records from the Hudson basin, including the Hudson River at Troy and Albany, and The Normans Kill, only historic occurrences have been recorded (NY Natural Heritage Program 2013). Although *L. cariosa* is not known from the Champlain basin, it is widespread in the St. Lawrence basin in northern New York. Records from elsewhere in the state are scattered. In 1895 it was reported from the "Delaware River system," and it is known from the Delaware basin in Pennsylvania (Ortmann 1919). *L. cariosa* may have occurred in the Passaic system in New York because it has been found just over the state line in the Ramapo River, New Jersey. Records of *L. cariosa* from central New York are questionable because of potential confusion with *L. cardium* however, records from "Oswego;" Oswego River (1887); Seneca River (1895); Cross Lake; and [Erie?] Canal, Rochester seem to be authentic. It is unclear whether *L. cariosa* reached the Oswego basin via the Erie Canal or was present in the basin in pre-Columbian times (Strayer and Jirka 1997).

Current	# of Animals	# of Occurrences	% of State
	__at least 875 live__	_25 waterbodies_	_16 of 56 HUC 8 watersheds_

Details of current occurrence:

L. cariosa is currently found in 25 waterbodies in New York State. It seems to be rare in the Hudson River, although it is still reproducing and common in the Susquehanna basin and lower Schoharie Creek. It also still occurs in several tributaries of the St. Lawrence in northern New York (Strayer and Jirka 1997).

In the Susquehanna basin, they were recently found in the main stem of the Susquehanna River, Butternut Creek, Canisteo River, Catatonk Creek, Chemung River, Chenango River, Genegantslet Creek, Otego Creek, Otselic River, Payne Brook, Sangerfield River, Schenevus Creek, Susquehanna River, Tigoa River, Tioughnioga River, East Branch Tioughnioga River, and the Unadilla River (Harman and Lord 2010, NY Natural Heritage Program 2013).

In the Hudson basin, it has been found post-1970 in Schoharie Creek and Indian Kill at Norrie Point. In the St. Lawrence River basin, it has been found in the Grass River, Little Salmon River, Oswegatchie River, Raquette River, St. Regis River, and West Branch Deer Creek. It has also been found in the Delaware River in the Delaware basin (NY Natural Heritage Program 2013).

Streams with high densities of *L. cariosa* include the Chenango River, Norwich and north; the Raquette River at Sugar Island and between Raymondville and Rooseveltown; and the Susquehanna River, especially at sites near Damascus, north of Windsor and east of Binghamton, and at Otego (NY Natural Heritage Program 2013, Harman and Lord 2010).

New York's Contribution to Species North American Range:

% of NA Range in New York	**Classification of New York Range**
____ **100 (endemic)**	__X__ **Core**
____ **76-99**	_ __ **Peripheral**
____ **51-75**	____ **Disjunct**
____ **26-50**	**Distance to core population:**
__X__ **1-25**	___________

IV. Primary Habitat or Community Type:

1. Medium River; Low-Moderate Gradient; Assume Moderately Buffered (Size 3+ rivers); Warm
2. Medium River; Low Gradient; Assume Moderately Buffered (Size 3+ rivers); Transitional Cool
3. Medium River; Low Gradient; Assume Moderately Buffered (Size 3+ rivers); Warm

Habitat or Community Type Trend in New York:

____ Declining ____Stable ____ Increasing __X__Unknown

Time frame of decline/increase: ____

Habitat Specialist? ___ ___ Yes __X___ No

Indicator Species? __x___ Yes ____ ___ No

Habitat Discussion:

In New York, *L. cariosa* lives in small to large rivers, especially in riffles (Ortmann 1919, Strayer 1993 in Staryer and Jirka 1997). It is often fairly abundant where it occurs. *L. cariosa* also lives in lakes in Maine, but no records are known from New York lakes (Strayer and Jirka 1997). Throughout its range, it has been found in medium to large rivers and lakes, including free-flowing rivers with rocky substrates. In the Connecticut River, it has been found in shallow water and areas more than 30 feet deep, usually in slow to moderate flow conditions. Within its core range in Massachusetts, it exhibited a distinct preference for sand and fine gravel substrates, and was proportionately more abundant in shallow sandbars than it was in nearby areas that were deeper and had a rocky or muddy substrate (Nedeau 2008).

V. New York Species Demographics and Life History

__X____ Breeder in New York

___X__ Summer Resident

__X___ Winter Resident

____ Anadromous

____ Non-breeder in New York

_____ Summer Resident

_____ Winter Resident

____ Catadromous

____ Migratory only

_____Unknown

Species Demographics and Life History Discussion:

Upstream males release sperm into the water. Females downstream take up the sperm with incoming water. Fertilization success may be related to population density, with a threshold density required for any reproductive success to occur. Eggs are fertilized within the female. Like nearly all North American mussels, *L. cariosa* must parasitize an often specific vertebrate host to complete its life cycle. It is suspected that some mussel populations are not recruiting because their hosts no longer occur with them. Once released by the female, glochidia must acquire a suitable host or die, usually within 24-48 hours. After attaching to a suitable host, glochidia encyst, usually at the fish's gills or fins and receive food and dispersal. Once the glochidia metamorphose into juveniles, they drop from the host. If they land in suitable substrate, they will burrow into the substrate, where they may remain for several years (Watters et al 2009).

In the adult form, freshwater mussels are basically sessile; movement is limited to a few meters of the lake or river bottom. The only time that significant dispersal can take place is during the parasitic phase. Infected host fishes can transport the larval unionids into new habitats, and can replenish depleted populations with new individuals. Dispersal is particularly important for genetic exchange between populations. Dispersal is likely to be a slow process for mussels which use resident fishes with limited home ranges as their hosts (COSEWIC 2003 in NatureServe 2013).

L. cariosa is bradytictic with eggs fertilized in the late summer and glochidia released the following spring. White perch (*Morone americana*) and yellow perch (*Perca flavescens*) may be the primary hosts. Other potential hosts include striped bass (*Morone saxatilis*), banded killifish (*Fundulus diaphanus*), chain pickerel (*Esox niger*), white sucker (*Catostomus commersonii*), smallmouth bass (*Micropterus dolomieu*), and largemouth bass (*Micropterus salmoides*). Longevity could exceed 20 years, with life spans exceeding 30 years not unlikely (Nedeau 2008).

VI. Threats:

This species is in decline almost everywhere it occurs (e.g. almost extirpated in CT, nearly extirpated in MA). In recent times, it is never found in high numbers. No direct harvest has occurred for this species. The species appears to be mildly tolerant of eutrophication and siltation but susceptible to toxins. Given extent or range, overall threats of declining water quality are limited. The introduced zebra mussel, *Dreissena polymorpha*, will have negative impacts on this species, especially in slow flowing waters of larger streams and in lakes (NatureServe 2013).

Agricultural Runoff
Roughly 25% of the total watersheds where L. cariosa is located is in agriculture (New York State Landcover 2010). Aquatic habitats lacking vegetated buffers of adequate width are threatened by runoff from urban areas, roads, lawns, and agricultural land (Gillis 2012). If best management practices are not closely adhered to, mussel habitat adjacent to wood harvest or agricultural land is subjected to pesticide, fertilizer, and silt/sediment runoff. During recent mussel surveys in Western and Central New York, it has been documented that sufficient vegetated riparian buffers are often lacking along known mussel streams (Mahar & Landry 2013), indicating that runoff is a major threat to resident mussel populations.

Species such as *L. cariosa* that have a mantle modified to attract host fish are thought to rely on the visual acuity of their fish hosts to facilitate transfer of glochidia from the female to the host. This indicates the potential importance of turbidity in interfering with reproduction (Nedeau 2008).

The presence of pesticides and fertilizers in our rural watersheds is nearly ubiquitous (Haag 2012). And because pesticides and their associated surfactants adsorb onto sediment particles, sedimentation may act as a vector for their transport into the aquatic system (Haag 2012). Mussels are more sensitive to pesticides than many other animals (Watters et al. 2009). Although effects of pesticides are species-specific, sub-lethal levels of PCBs, DDT, malathion, and other compounds inhibit respiratory efficiency and accumulate in the tissues. Atrazine and permethrin at sublethal concentrations reduced juvenile growth (Bringolf et al. 2007a, 2007b) and environmental levels of atrazine altered mussel movement and aggregation behavior (Flynn and Spellman 2009). Pesticides can affect mussels in many ways, but the full range of long-term effects remains unknown (Haag 2012).

Fertilizer runoff is also a concern. High inputs of nitrogen from fertilizers can cause increases in ammonia in the water and the substrate, leading to direct toxicity for a wide range of mussel species. Mussels, especially in their early life stages, are more sensitive to un-ionized ammonia than other organisms, and high sensitivity is seen across a range of species and life histories (Haag, 2012). In addition, ammonia adsorbs to sediment particles, resulting in higher nitrogen concentrations in the substrate than in the overlying water. The nitrogen present in the interstitial spaces in the substrate is thought to result in juvenile mortality and to prevent recruitment by some mussel species (Strayer and Malcom 2012). Studies have suggested decreasing sediment loads entering aquatic systems as the best way to decrease the impact of numerous stressors for mussels in general (Roley et al. 2012).

Runoff from Developed Land

Nearly all of the *L. cariosa* habitat is intermittently bordered by interstate highways, state routes, and several local roads. In addition, the habitat of *L. cariosa* receives stormwater runoff from the cities of Hornell, Elmira, Corning, Binghamton, Oneonta, Norwich, Potsdam, Massena and Morrisville, either directly or through tributaries (New York State Landcover 2010). These developed lands are likely sources of stormwater runoff containing metals and road salts. Mussels are particularly sensitive to heavy metals, more so than many other animals used in toxicological tests (Keller & Zam 1991). Low levels of metals may interfere with the ability of glochidia to attach to the host (Huebner & Pynnonen 1992), suggesting that U.S. EPA ambient water quality criteria may not adequately protect mussels from toxic metals (Wang et al., 2011). In addition, increases in salinity from the runoff of salt used for clearing roads in winter may be lethal to glochidia and juvenile mussels (Keller & Zam 1991; Liquori & Insler 1985; Pandolfo et al. 2012). Based on these studies, the U.S. EPA's ambient water quality criterion for acute chloride exposures may not be protective of all freshwater mussels (Pandolfo et al. 2012).

Treated Waste Water

The habitat of *L. cariosa* receives treated waste water from the cities of Hornell, Elmira, Corning, Binghamton, Oneonta, Norwich, Potsdam, Massena and Morrisville either directly or through tributaries (SPDES 2007). Recent studies show that mussel richness and abundance decrease with increased proximity to sewage effluent (Wildenberg 2012). The input of biomaterial from waste water treatment plants depletes dissolved oxygen levels, negatively impacting mussels. Ammonia from wastewater treatment plants has been found to be toxic to glochidia (Goudraeu et al. 1993) and at sub-lethal exposure adult mussels exhibit decreased respiratory efficiency (Anderson et al. 1978). Endocrine disrupters from pharmaceuticals are also present in municipal sewage effluents and are increasing common in rivers and lakes (Haag 2012). In mussels, chronic exposure to estrogenic compounds in effluents caused feminization of male mussels, but these individuals did not produce eggs, suggesting major disruption of reproductive function (Gagne et al. 2011). The long term effects of these compounds on mussels are unknown (Haag 2012). It should be noted that in the Susquehanna basin, Harman and Lord (2010) found no evidence that waste water treatment plants were responsible for reductions in mussel species of greatest conservation need.

Flood Control Projects

Within the habitat of *L. cariosa,* large stretches of Rivers are in leveed, water control projects, requiring periodic maintenance, For example the Canisteo and Chemung rivers in the Southern Tier of New York State("New York State Flood Protection" 2013). Additionally, many smaller streams have been channelized and bermed by landowners and highway departments to protect farm fields and other structures. These structures confine larger rivers, preventing the river from inundating its natural floodplains and wetlands to minimize flood damage. Channelization and dredging associated with flood control projects are catastrophic to mussels and have been implicated in the decline of some populations (Watters et al. 2009). The result of these projects is altered seasonality of flow and temperature regimes, increased stream velocities, unstable substrates, changed patterns of sediment scour and deposition, including streambank erosion, altered transport of particulate organic matter (the food base for mussels), and a general degradation of stream habitat (Benke 1999; Yeager 1993; Nedeau 2008).

Other Ecosystem Modifications

Ecosystem modifications, such as isolated occurrences of canal dredging, instream work associated with bridge replacement, gravel removal, and vegetation removal kill mussels and destroy their habitat. For example, dredging for vegetation removal has been shown to remove up to 23% of mussels in spoils (Aldridge 2000). Further evidence for disruption was provided by mussel surveys adjacent to approximately 20 river miles of Conewango Creek that had been channelized and straightened in the first half of the 20th century. The resulting "dredge" had no riffle or run habitat and sites just below and above this channelized section contained few or no mussels (The Nature Conservancy 2009). Although limited in geographic scope these habitat modification activities have long term impacts on mussels and their distribution (Aldridge 2000).

Climate Change

The NatureServe Climate Change Vulnerability Index has been used in several states to help identify species that are particularly vulnerable to the effects of climate change. While *L. cariosa* vulnerability was not evaluated for New York, populations within Pennsylvania are ranked as "highly vulnerable" to climate change (2013).

Impoundments - Range wide

Across its range, impoundments likely contributed to the reduced distribution of mussels that we see today. Vaughn and Taylor (1999) observed a mussel extinction gradient with a gradual, linear increase in mussel species richness and abundance with increasing distance downstream from impoundments. Species and their hosts that require shallow, oxygenated, fast-flowing water quickly are eliminated. Continuously cold water from both increased water depth upstream of the dam and dam discharges downstream of the dam may prevent reproduction. Impoundment increases silt load and eutrophication, resulting in changes in the fish fauna, and therefore the availability of hosts. Dams represent distributional barriers to fish hosts, and therefore to the mussels themselves. The zoogeographic patterns of several species suggest a dam-limited range. Dams also act as sediment traps, often having many feet of silt and debris caught on their upstream side. These areas generally are without mussels. Below the dam, the tailwaters often have dense mussel beds, as these reaches are the only areas left that still have oxygenated, fast moving water. This is exemplified by the distribution of beds in the lower Muskingum River, Ohio (Stansbery & King 1983; ESI 1993c).

In addition, improperly sized and poorly installed or poorly maintained culverts have impacts similar to dams in that they fragment habitat, preventing the movement by host fish, and effectively isolating mussel populations. And because culverts are located at nearly every road-stream intersection, there is the potential for landscape level fragmentation of mussel habitat.

Hybridization

Specimens thought to be *Lampsilis cariosa* from the Potomac River Basin in Maryland may be hybridizing with *Lampsilis cardium* or *Lampsilis ovata* (introduced to the Potomac Basin) (Art Bogan pers. comm. 1998). Anatomical or genetic work needs to be done to understand this situation. A portion of collections may have shell material mis-identified as another *Lampsilis* (Author pers. obs. 1998). In North Carolina, Stiven and Alderman (1992) noted conchological and genetic differences of specimens from different habitats as well as significant differences from *Leptodea ochracea* and *Lampsilis radiata* (NatureServe 2013).

Are there regulatory mechanisms that protect the species or its habitat in New York?

______ No ____ Unknown

__X__ Yes

Mussel habitats receive some generic protection under several New York State regulations (NYCRR) promulgated under the authority of the New York Environmental Conservation Law (ECL), specifically Part 608 of the NYCRR: Use and Protection of Waters, and Part 617 of the NYCRR: State Environmental Quality Review (SEQR). Part 608 provides protection of some mussel habitats by regulating and requiring environmental review of the modification or disturbance of any "protected stream", its bed or bank, and removal of sand, gravel or other material from its bed or banks (608.2 Disturbance of Protected Streams). This does not provide adequate protection of mussels and their habitats as it only protects streams or particular portions of a streams for which there has been adopted by NYSDEC or any of its predecessors any of the following classifications or standards: AA, AA(t), A, A(t), B, B(t) C(t), or Streams designated (t)(trout) also include those more specifically designated (ts)(trout spawning). Mussels habitats may also receive some additional protections as the construction, repair, breach or removals of dams, and the excavation and placement of fill in navigable waters are subject to regulation and environmental review under Part 608, 608.3 and 608.5 respectively. Under part 608, projects requiring a permit can be conditioned by NYSDEC to include best management practices, such as sediment and erosion protections. Through the review process, these projects can also be modified to reduce impacts in order to meet permit issuance standards.

Under Part 608, protection of unlisted species of mussels is general and relatively limited. More importantly, Class C and D waters with mussels do not receive protection under these regulations. A significant portion of the New York's mussel resources occur within Class C and D waters. Approximately 40% of waterbodies containing *L. cariosa* are considered "unprotected" streams (Standards C and D). An additional but not insignificant gap in protection occurs because agricultural activities consisting of the crossing and re-crossing of a protected stream by livestock or wheeled farming equipment normally used for traditional agricultural purposes or of withdrawing irrigation water in a manner which does not otherwise alter the stream, are exempt from these regulations and environmental review.

Water quality certifications required by Section 401 of the Federal Water Pollution Control Act, Title 33 United States Code 1341(see subdivision (c)of this Section)may provide protection for freshwater mussels and their habitats from some activities that would potentially have adverse impacts by regulating construction or operation of facilities that may result in any discharge into navigable waters. Water quality certifcations set water quality-related effluent limitations, water quality standards, thermal discharge criteria, effluent prohibitions and pretreatment standards for projects on navigable waters.

The State Environmental Quality Review (SEQR, Part 617 NYCRR) may also protect mussels and their habitats by requiring the consideration of environmental factors into the existing planning, review and decision-making processes of state, regional and local government agencies for activities that require discretionary approval. SEQR requires the preparation of an Environmental Impact Statement, including an alternatives analysis, for those activities that may result in a substantial adverse change in ground or surface water quality; a substantial increase in potential for erosion, flooding, leaching or drainage problems; the removal or destruction of large quantities of vegetation or fauna; substantial interference with the movement of any resident or migratory fish or wildlife species; impacts on a significant habitat area; substantial adverse impacts on a threatened or endangered species of animal or plant, or the habitat of such a species; other significant adverse impacts to natural resources; or, a substantial change in the use, or intensity of use, of land including agricultural, open space or recreational resources, or in its capacity to support existing uses.

New York State has numerous laws and regulations that both directly or indirectly protect waters of the state (mussel habitats) including regulations governing direct discharges to surface and groundwater, storm water, agricultural activities, pesticides, flood control, and dams. Without these regulations, mussels would certainly be in worse shape; however, most of these generic protections are not adequate in scope or specific enough to mussel threats to protect the mussel resources of New York State

Describe knowledge of management/conservation actions that are needed for recovery/conservation, or to eliminate, minimize, or compensate for the identified threats:

- Modify marine mussel regulations or the definition of protected wildlife in NYCRR to clarify that freshwater mussels are protected under ECL. Current regulations could be interpreted that freshwater mussels may only be protected as shellfish without a season within the Marine District.

- Through landowner incentive programs or regulation, riparian buffers should be added/maintained/widened, along agricultural fields, subdivisions, and along major roads to decrease the levels of nitrogen, pesticides, sediment, heavy metals, salts from entering these aquatic systems , as well as to moderate water temperature. Studies have suggested decreasing sediment loads entering aquatic systems as the best way to decrease the impact of numerous stressors for mussels in general (Roley et al., 2012).Coordinate with local wastewater treatment facilities to improve ammonia removal of treated discharge. This has been documented as a threat to Unionids at multiple life stages, and therefore needs to be addressed (Gillis, 2012).

- Require all state agencies to maintain appropriate vegetative buffers along streams, rivers and lakes on state-owned or state managed properties.

- Develop and implement a comprehensive monitoring strategy that identifies protocols, including locations and specific intervals, for regular monitoring of known mussel populations to detect assess trends and detect dangerous declines.

- Mussel sensitivity to particular pollutants should be considered or addressed in the regulation of wastewater and stormwater discharges to groundwater and surface waters, State Pollutant Discharge Elimination Systems (SPDES). This should be reflected in effluent limitations for discharges, including discharges from P/C/I facilities (Private/Commercial/Industrial), CAFO facilities (Concentrated Animal Feeding Operations), High Volume Hydraulic Fracturing Discharges, and Wastewater treatment plants, etc. Discharges whose receiving waters have mussels, particularly those with known populations of mussels listed as Endangered, Threatened, Special concern or SGCN, should be carefully reviewed for potential impacts to mussels. For example, deleterious levels of ammonia (a component of many types of discharges) and molluscicides (a commonly used water treatment chemical in discharged water) should not be permitted.

- Coordinate with local wastewater treatment facilities to improve ammonia removal of treated discharge. This has been documented as a threat to Unionids at multiple life stages, and therefore needs to be addressed (Gillis, 2012).

- NYSDEC should consider sensitivity of freshwater mussels to specific pollutants in the establishment and setting of water quality standards and TMDLs for waters containing freshwater mussels. A Total Maximum Daily Load (TMDL) specifies the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. TMDLs account for all contributing sources (e.g. point & nonpoint sources, and natural background levels), seasonal variations in the pollutant load, and incorporate a margin of safety that accounts for unknown or unexpected sources of the pollutant. In essence, a TMDL defines the capacity of the waterbody to absorb a pollutant and still meet water quality standards. The Clean Water Act requires states to identify waterbodies that do not meet water quality standards after application of technology-based effluent limitations. For these "impaired waters," states must consider the development of alternative strategies, including TMDLs, for reducing the pollutants responsible for the failure to meet water quality standards.

The Comprehensive Wildlife Conservation Strategy (NYSDEC 2006) includes recommendations for the following actions for freshwater mussels:

Habitat management:

- Manage areas of important mussel populations by controlling degradation factors (e.g.. Controlling livestock access, point source or non-point source pollution, flow alteration, etc.)
- Develop methods to improve and restore freshwater bivalve habitat.

Habitat research:

- Conduct research to determine habitat parameters necessary for good populations of each species of species-at-risk listed mussels.
- Research flow requirements of freshwater bivalves and model the effects of flow changes both in volume and timing.
- Research all parameters of mussel habitat requirements including temperature, substrate, fish, flow, food, etc.

Habitat restoration:

- Restore degraded habitat areas to allow for recolonization or reintroduction of listed mussels.

Invasive species control:

- Develop a monitoring/control plan that includes measures to detect invasive species problematic to freshwater bivalves in all New York watersheds and actions that will be taken to control them before they become threats.

- Conduct research on control of exotic bivalve species that compete with native mussels and exotic crustaceans or fish which may prey on them.

Life history research:

- Research effects of pesticides and other chemicals, including ammonia, on all life stages of freshwater bivalves: sperm/egg, glochidia, larva, adults.
- Research potential interbreeding between *Alasmidonta varicosa* and *Alasmidonta marginata* and, if occurring, evaluate the potential threat to *A. varicosa* population integrity.
- Determine fish hosts for species where this is not known for populations living in New York.
- Research population dynamics of listed mussel species including connectivity of populations or subpopulations and genetic distinctness of populations or subpopulations.
- Determine or confirm breeding phenology and habitat conditions necessary for successful breeding for listed mussels (e.g.. mussel density, pop. level of fish host, temp, flow).

Modify regulation:

- Modify marine mussel regulations to be clearer that freshwater mussels are protected under ECL.

New regulation:

- Ban the importation of fish that feed on freshwater mollusks (e.g.. black carp).
- Require inclusion of all stages of freshwater mussels in testing for approval of new pesticides in New York.

Other action:

- Develop an outreach program to private landowners through the Landowner Incentive Program to educate the public about freshwater mussel protection and initiate projects to prevent or repair impacts from land use on mussels.
- Increase regional permit control of development and highway projects that may impact native mussels.
- Develop standard monitoring/survey protocols for development projects in all watersheds in New York.
- Evaluate threats to mussels in each New York watershed and prioritize areas for actions to address the threats.
- Research the best survey methods both for detection of rare species and evaluation of population status and trends.
- Begin evaluation of members of the family Sphaeridae (fingernail clams) for inclusion into the species at risk list.

Population monitoring:

- Conduct population estimates of species-at-risk listed mussel species in NY
- Conduct surveys to determine distribution of species-at-risk listed mussel species in NY.

Regional management plan:

- Incorporate freshwater mussel goals and objectives into regional water quality and fish management plans and policies.

Relocation/reintroduction:

- Where appropriate, reintroduce listed mussels into appropriate habitat within their historic range.

Statewide management plan:

- Incorporate freshwater mussel goals and objectives into statewide water quality and fish management plans and policies.

VII. References

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