Species Status Assessment

Class: **Bivalvia**
Family: **Unionidae**
Scientific Name: ***Alasmidonta varicosa***
Common Name: **Brook floater**

Species synopsis:

Alasmidonta varicosa belongs to the subfamily Unioninae, diagnosed by the presence of subtriangular glochidia with large, medial hooks, and the tribe Anodontini, which includes 16 extant and 1 likely extirpated New York species of the genera Alasmidonta, Anodonta, Anodontoides, Lasmigona, Pyganodon, Simpsonaias, Strophitus, and Utterbackia (Haag 2012, Graf and Cummings 2011). *A. varicosa* is closely related to and is often confused with *Alasmidonta marginata* (Simpson 1914). Systematics of the genus have not been reviewed genetically.

A. varicosa is one of the most endangered mussels in Northeastern America. It is listed as endangered in Massachusetts, Connecticut, New Hampshire, and New Jersey, threatened in Vermont and New York, and ranked as vulnerable throughout its range (Nedeau 2008). Since 1970, it has been found in 17 New York waterbodies in the Susquehanna and Delaware basins, and to a limited extent in the Connecticut coastal basin (Jirka 1991, Strayer and Jirka 1997). It is more commonly found in nutrient poor streams with low to moderate flow velocities and good water quality (Strayer and Jirka 1997, Nedeau 2008). Where it is found, it is usually uncommon (Strayer and Jirka 1997).

I. Status

a. Current and Legal Protected Status

i. **Federal** ______None______________________________ **Candidate?** ___No___

ii. **New York** _____Threatened – Species of Greatest Conservation Need_______

b. Natural Heritage Program Rank

i. **Global** ____G3 - Vulnerable____

ii. **New York** ____S1 – Critically imperiled__ **Tracked by NYNHP?** __Yes___

Other Rank:

Committee on the Status of Endangered Wildlife in Canada (COSEWIC): Special Concern (2009)
American Fisheries Society Status: Threatened (1993)

Species of Regional Northeast Conservation Concern (Therres 1999)

Status Discussion:

Significant declines have been noted in Massachusetts, New York, Pennsylvania, New Jersey, Rhode Island, Virginia, North Carolina, and South Carolina. Approximately 70-90 site extirpations (of 150 or more known historically) have occurred globally with only a portion of the remaining sites holding healthy, viable populations. Although precise area of occupancy is not known and precise extent of decline is not known with accuracy, the loss of historical sites is indicative of a significant decline in area of occupancy over the last century (likely greater than 50% area of occupancy and range). Some good populations are known in the north (Vermont, and particularly Maine and a very large population just discovered in New Hampshire plus nine new populations in New Brunswick and Nova Scotia) where the species is stable but declining even in the more stable portions of its range (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: ____

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**

__x__ declining ____increasing ____stable ____unknown

ii. **Distribution:**

___x__ declining ____increasing ____stable ____unknown

Time frame considered: ____
Listing Status: ___S1 Endangered______________________ SGCN? ___Yes_______

MASSACHUSETTS **Not Present** ______ **No data** ______

i. **Abundance**

__x__ **declining** ____**increasing** ____**stable** ____**unknown**

ii. **Distribution:**

__x__ **declining** ____**increasing** ____**stable** ____**unknown**

Time frame considered: ____

Listing Status: S1 Endangered SGCN? Yes

NEW JERSEY **Not Present** ______ **No data** ______

i. **Abundance**

__x__ **declining** ____**increasing** ____**stable** ____**unknown**

ii. **Distribution:**

__x__ **declining** ____**increasing** ____**stable** ____**unknown**

Time frame considered: ____

Listing Status: S1 Endangered SGCN? Yes

ONTARIO **Not Present** __X__ **No data** ______

PENNSYLVANIA **Not Present** ______ **No data** ______

i. **Abundance**

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

ii. **Distribution:**

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

Time frame considered: Since 1980 (PA Natural Heritage Program fact sheet)

Listing Status: S2 SGCN? No

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

VERMONT **Not Present** _________ **No data** ________

i. **Abundance**

___x__ declining ____increasing ____stable ____unknown

ii. **Distribution:**

___x__ declining ____increasing ____stable ____unknown

Time frame considered: ____
Listing Status: ____S1 - Threatened______________________ SGCN? ___Yes___

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 New York 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 and 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.

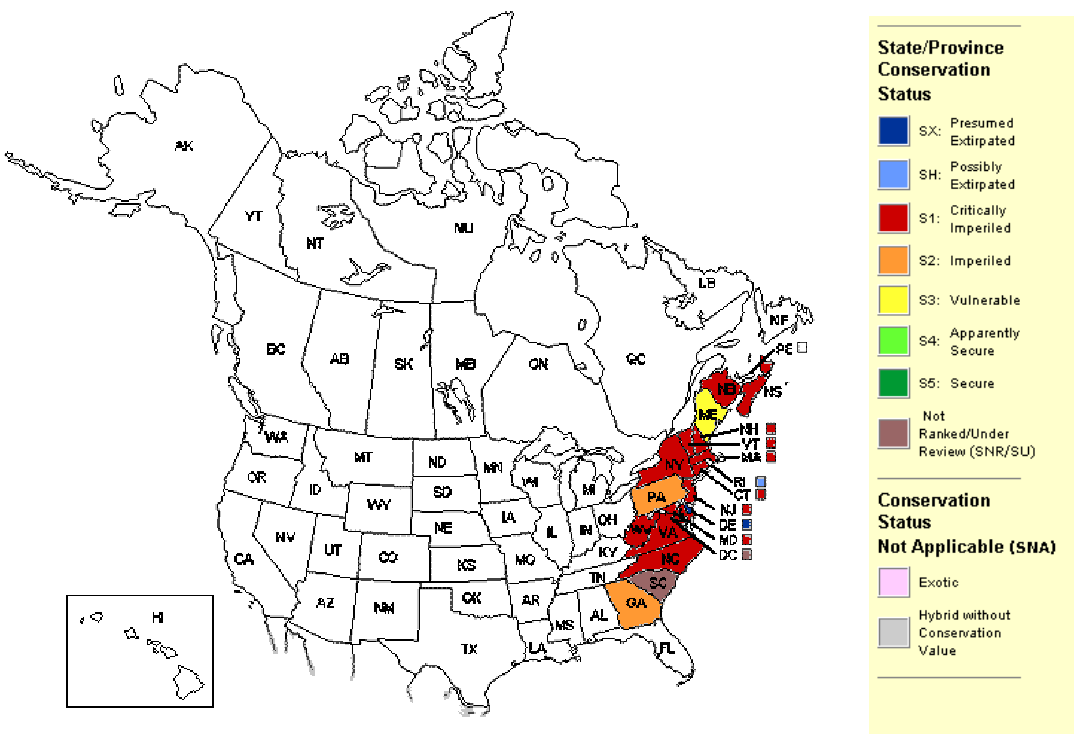

Figure 1. *A. varicosa* distribution in North America (NatureServe 2013).

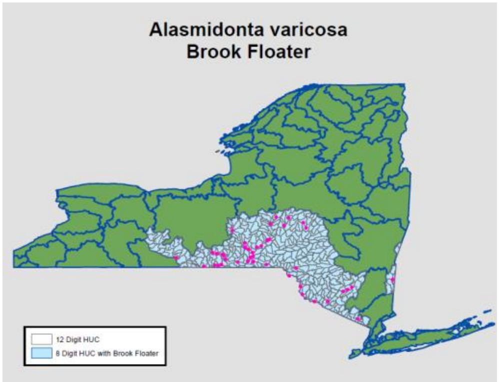

Figure 2. Post 1970 distribution of *A. varicosa* in New York York (Mahar and Landry 2013, Harman and Lord 2010, The Nature Conservancy 2009, New York Natural Heritage Program 2013, White et al. 2011).

III. New York Rarity, if known:

Historic	# of Animals	# of Locations	% of State
prior to 1970	unknown	~10 waterbodies	9 of 56 HUC 8 watersheds
prior to 1980	________	________	________
prior to 1990	________	________	________

Details of historic occurrence:
In New York, populations in the Housatonic and Passaic basins have apparently disappeared and surveys of eleven historic populations in the Susquehanna basin in 1991 and 1995 turned up only one living animal (Jirka, 1991; Strayer and Jirk, 1997). New York Natural Heritage Program (2013) reported that *A. varicosa* was found in the Unadilla River in late 1960s and in Oaks Creek Index prior to 1935, but in recent surveys no evidence of this species was found in these streams. Populations in the upper Delaware basin and in the Shawangunk Kill in the Hudson basin were sparse and limited in extent (Strayer and Jirka 1997).

Current	# of Animals	# of Locations	% of State
	>100,000 live	17 waterbodies	10 of 56 HUC 8 watersheds

Details of current occurrence:
A. varicosa currently exists in 17 different waterbodies in New York State (Figure 2).

Since 1970, *A. varicosa* has been found in the Susquehanna basin in Sangerfield River (2 sites: 6 live 2008), Chenango River (at least 5 sites: live 2008), Tioughnioga River (live 1996), Otselic River above Whitney Point Dam (1 site: 1 live 1996), and Catatonk Creek (7 sites: at least 18 live 1996) (NY Natural Heritage Program, 2013). In a recent survey of the Susquehanna basin, Harman and Lord (2010) also found live *A. varicosa* in the main stem of the Susquehanna River (at least 5 sites:

23 live), Chenango River, Chemung River (at least 5 sites: 5 live), and West Branch Tioughnioga River (1 site: 2 live).

In the Delaware basin, *A. varicosa* has been found in the Lower Beaver Kill East Branch (1 site: 1 live 2011), East Branch of the Delaware River (1 site: 2 live), its tributary, Twadell Brook, Delaware River from Hancock to Jarvis Point (7 sites: 9 live 2002), and the Neversink River between Woodbridge and Huguenot (13 sites, 129 live 2002), as well as its tributary, Sheldrake Stream (NY Natural Heritage Program 2013). In New York, only the Neversink River population is large, at approximately 100,000 animals (Strayer and Jirka 1997).

This species has also been found in Upper Hudson basin at Shawangunk Kill (3 sites: 4 live 1992, but not since), the Lower Hudson basin at Mahwah River (old shell 1994), and in the Connecticut coastal basin at Waebatuck and Wassaic Creeks (old shell 2010) (NY Natural Heritage Program 2013).

New York's Contribution to Species North American Range:

% of NA Range in New York	**Classification of New York Range**
____ 100 (endemic)	**____ Core**
____ 76-99	**__X__ Peripheral**
____ 51-75	**____ Disjunct**
____ 26-50	**Distance to core population:**
__X__ 1-25	**__145 miles__**

IV. Primary Habitat or Community Type:

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

Habitat or Community Type Trend in New York:

____ Declining ____Stable ____ Increasing __X___Unknown

Time frame of decline/increase: ____

Habitat Specialist? __X__ Yes ______ No

Indicator Species? __X__ Yes _____ No

Habitat Discussion:

A. varicosa is strictly a running-water species and never occurs in lakes or reservoirs. It is said to favor gravelly riffles, sandy shoals, and stable habitats such as coarse sand and gravel in creeks and small rivers (Clarke 1981, Nedeau et al. 2000, Strayer and Jirka 1997), although Strayer and Ralley (1993) found no consistent substrate preference. It is thought to prefer low to moderate flow velocities. In fast water, they often will be found clustered in protected areas such as behind boulders and near banks (Nedeau 2008).

In general, *A.varicosa* is more common in upper portions of large watersheds with intact upland forest but is absent from headwater streams and high-gradient river reaches prone to scour (Nedeau 2008). It is found most frequently in nutrient-poor streams with low calcium levels, low nutrients, and good water quality (Nedeau 2008, Strayer and Jirka 1997). This species may be intolerant of the many stressors related to dams, urban areas, and other land uses that affect the quality of water and habitat (Nedeau 2008). Where it occurs, it is usually uncommon (Strayer and Jirka 1997).

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, *A.varicosa* 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 habitat, they will burrow into the substrate, where they may remain for several years (Watters et al. 2009).

While passive movement downstream may occur, 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 as cited in NatureServe 2013).

This species has a periodic life history strategy, characterized by moderate to high growth rate, low to intermediate life span, age at maturity, and fecundity, but generally smaller body size than opportunistic species. Most species are long-term brooders. This life history strategy is considered an adaptation to allow species to persist in unproductive habitats or habitats that are subject to large-scale, cylindrical environmental variation or stress (Haag 2012).

This species is bradytictic, with fertilization occurring in the summer (August) and glochidia released the following spring (May) (Nedeau 2008, Clarke, 1981, Ortmann 1919). In Maine, release of glochidia occurs from April to June (and possibly later) (Nedeau et al. 2000). Probable hosts include long-nose dace (*Rhinichthys cataractae*), black-nose dace (*Rhinichthys atratulus*), slimy sculpin (*Cottus cognatus*), golden shiner (*Notemigonus crysoleucas*), pumpkinseed (*Lepomis gibbosus*), yellow perch (*Perca flavescens*), margined madtom (*Noturus insignis*), and tessellated darter (Nedeau, 2008, Strayer and Jirka 1997). No studies, however, have confirmed glochidial host transformation under natural conditions (NatureServe 2013). The life span of *A. varicosa* may be similar to that of *Alasmidonta marginata*, 12 years.

VI. Threats:

Agricultural Runoff

Agricultural practices in the basins with *A. varicosa* populations may be sources of siltation and pollution. Although only 27 percent of the land in the New York portion of the Susquehanna basin is agriculture (Homer et al. 2007) the large majority of this agriculture is located adjacent to streams, many of which are identified as *A. varicosa* habitat. While this holds for most streams in the basin, it is particularly true of the Chenango River, and Catatonk Creek, and portions of the Susquehanna River (New York State Landcover 2010). Most of the Delaware basin is in forest land, however, land adjacent to the lower reaches of the Neversink River, where New York's largest *A. varicosa* populations are found, is dominantly cultivated cropland. The land adjacent to where *A. varicosa* has been found in the Shawangunk Kill, Lower Hudson, is a mix of cultivated crops, pasture, and developed land (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 and Landry, 2013), indicating that runoff is a major threat to resident mussel populations.

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

All 17 New York waterbodies that host *A. varicosa* populations are intermittently bordered by interstate highways, state routes, and/or local roads, and residences (New York State Landcover 2010). *A. varicosa* habitat receives storm water runoff from the municipalities of Corning, Painted Post, Cortland, Endicott, Waverly, Binghamton and its suburbs, Whitney Point, Green, and Norwich in the Susquehanna basin; Callicoon and Port Jarvis in the Delaware basin; and Crawford in the lower Hudson Basin (New York State Landcover 2010). These developed areas are likely sources of stormwater runoff containing metals and road salts (Gillis 2012). Mussels are particularly sensitive to heavy metals, more so than many other animals used in toxicological tests (Keller and Zam 1991). Low levels of metals may interfere with the ability of glochidia to attach to the host (Huebner and 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 and Zam 1991, Liqouri and 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 and Untreated Waste Water

In the Susquehanna basin, known *A. varicosa* sites are located downstream from nine City of Binghamton combined sewer outflow (CSO) outfalls ("Combined Sewer Overflow" 2012). In addition, *A. varicosa* habitat receives storm water runoff and treated waste water from the municipalities of Corning, Painted Post, Cortland, Endicott, Waverly, Binghamton and its suburbs, Whitney Point, Green, and Norwich in the Susquehanna basin; Callicoon and Port Jarvis in the Delaware basin; and Crawford in the lower Hudson basin (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

In the Susquehanna basin, large stretches of *A. varicosa* habitat has been found within or adjacent to stream reaches shaped by levee and/or floodwall flood control projects in Gang Mills on the Tioga River, Corning/Painted Post on the Chemung River, Nichols on the Susquehanna River, Vestal on the Susquehanna River, Binghamton on the Susquehanna and Chenango Rivers, Port Dickinson and Oxford on the Chenango River, and Whitney Point on the Tioughnioga River ("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 Habitat Modifications

In addition to channelization and regular channel dredging for maintenance of flood control structures, other ecosystem modifications such as instream work associated with bridge replacement 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).

Invasive Species

Invasive zebra mussels (*Dreissena polymorpha*) pose a threat to *A. varicosa* populations in the Chenango River, particularly downstream of Eastonbrook Reservoir in Madison County, the West Branch of the Tioughnioga River near Cortland, and in the Susquehanna River at Binghamton and south of Copperstown (Harman and Lord 2010, iMapInvasives, 2013). Harman and Lord (2010) note that zebra mussels are moving downstream from these headwater areas on the Susquehanna and are fouling and killing native pearly mussels. Zebra mussels have been repeatedly cited as a threat to native mussel populations (Strayer and Jirka 1997, Watters et al. 2009). En masse, Dreissenids outcompete native mussels by efficiently filtering food and oxygen from the water. They reduce reproductive success by filtering native mussel male gametes from the water column and they can foul the shells of the native mussels to the point that their valves can no longer open. In heavily invested areas, they may transform a habitat by hardening the substrate, such that dislodged mussels are not able to rebury (USFWS 1994).

Didymo (*Didymosphenia geminata*), a filamentous diatom, can form extensive mats that can smother stream bottoms and occlude habitat for mussels (Nedeau 2008) This invasive has been found in the East Branch of the Delaware River. If it becomes as abundant in the Delaware Basin as it has elsewhere, it could have enormous negative consequences for mussels, including *A. varicosa* (Nedeau 2008).

Water Temperature Changes

Temperature induced changes in fish communities could have a profound influence on the availability of hosts for freshwater mussels. Mussels, like *A. varicosa*, that inhabit small streams and rivers and rely on fish adapted for cooler water, such as several species of dace, minnows, sculpins, and darters, might be most affected by factors such as climate change or the removal of shaded buffers (Nedeau 2008). Pandolfo (2008) preformed a study in which the upper and lower temperature thresholds from several species of mussels, including *A. varicosa*, were determined. It was discovered that, compared to the other species tested, *A. varicosa*, seemed to be the most thermally tolerant, however, in a recent assessment of New York's at-risk species to climate change, Schlesinger et al. (2011) ranked *A. varicosa* as "extremely vulnerable". This indicates that abundance and/or range extent within New York is extremely likely to substantially decrease or disappear by 2050. Gailbreth et al. (2010) recently showed how regional climate patterns coupled with changing local water regimes and management strategies have shifted mussel populations from thermally sensitive species to thermally tolerant species.

Impoundments – Range wide

Range wide, impoundments likely contributed to the reduced distribution 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 and 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.

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

_______ No   _____ Unknown

__X___ Yes

New York State Environmental Conservation Law, § 11-0535. 6 NYCRR Part 182: Endangered and Threatened Species of Fish and Wildlife; Species of Special Concern; Incidental Take Permits

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). Mussel 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. 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 certifications 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, particularly those that also provide shade, should be added/maintained/widened, along agricultural fields, subdivisions, and along major roads to decrease the levels of nitrogen, pesticides, sediment, heavy metals, and 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).

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

- 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).

- Establish a protocol where as DEC staff work closely with Flood control management to reduce or impacts to native mussels during maintenance flood control projects.

- Update wastewater treatment facilities in Binghamton to eliminate combined sewer outflows.

- Monitor the Delaware River system for the spread of Didymo.

- Replace culverts that disrupt aquatic habitat connectivity to allow for passage of small fish species.

- 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 and 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.

- 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.

- 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.

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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