Species Status Assessment

Class: **Bivalvia**
Family: **Unionidae**
Scientific Name: ***Villosa iris***
Common Name: **Rainbow**

Species synopsis:

Villosa iris 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). *Villosa iris* belongs to the genus *Villosa,* which was originally characterized for their rough periostracum, but has evolved into a clade with many examples of smooth exteriors. *Iris* refers the iridescent nacre characteristic of this species (Watters et al. 2009).

V.iris is typically a species of creeks and small rivers, but can sometimes occur in lakes and large rivers (Strayer and Jirka 1997). It prefers moving water and highly oxygenated waters (Strayer and Jirka 1997, Mahar and Landry 2013). Since 1970, this species has been found in 27 waterbodies. *V.iris* currently inhabits the lower Genesee, Lake Erie, West and Mid Lake Ontario, and the Oswego basins, as well as the Erie Canal and may occur in the Allegheny basin (Mahar and Landry 2013, NY Natural Heritage Program 2013). Portions of the New York range that have been recently surveyed show abundant populations of *V.iris (*Strayer and Jirka 1997).

In New York, *V. iris* is ranked as imperiled, although it is apparently secure throughout its range (NatureServe 2013). In North America, approximately ⅔ 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** ____G5 - Secure ____

ii. **New York** __S2S3 – Imperiled/Vulnerable__ **Tracked by NYNHP?** __Yes__

Other Rank:

Committee on the Status of Endangered Wildlife in Canada (COSEWIC): Endangered (2006)
American Fisheries Society Status: Currently Stable (1993)

Status Discussion:

This species is found throughout the Tennessee, Cumberland, and Ohio River basins, the upper Mississippi River, and the St. Lawrence River system from Lake Huron to Lake Ontario including their tributaries and is considered stable in much of its range but is declining significantly in Canada (NatureServe 2013).

II. Abundance and Distribution Trends

a. North America

i. **Abundance**

____ declining ____increasing __x__stable ____unknown

ii. **Distribution:**

____ declining ____increasing __x__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 __X__** **No data _______**

MASSACHUSETTS **Not Present __X__** **No data _______**

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

ONTARIO **Not Present ________** **No data _______**

i. Abundance

__X__ declining ____increasing ______stable ____unknown

ii. Distribution:

__X__ declining ____increasing ______stable ____unknown

Time frame considered: Last 30 years, last 10 have become limited stable
Listing Status: S2S3 Federally and Provincially Endangered

PENNSYLVANIA **Not Present** ________ **No data** _______

i. **Abundance**

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

ii. **Distribution:**

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

Time frame considered: ____

Listing Status: __S1 -PA Biological Survey recommends listing as Endangered SGCN? _No__

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 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.

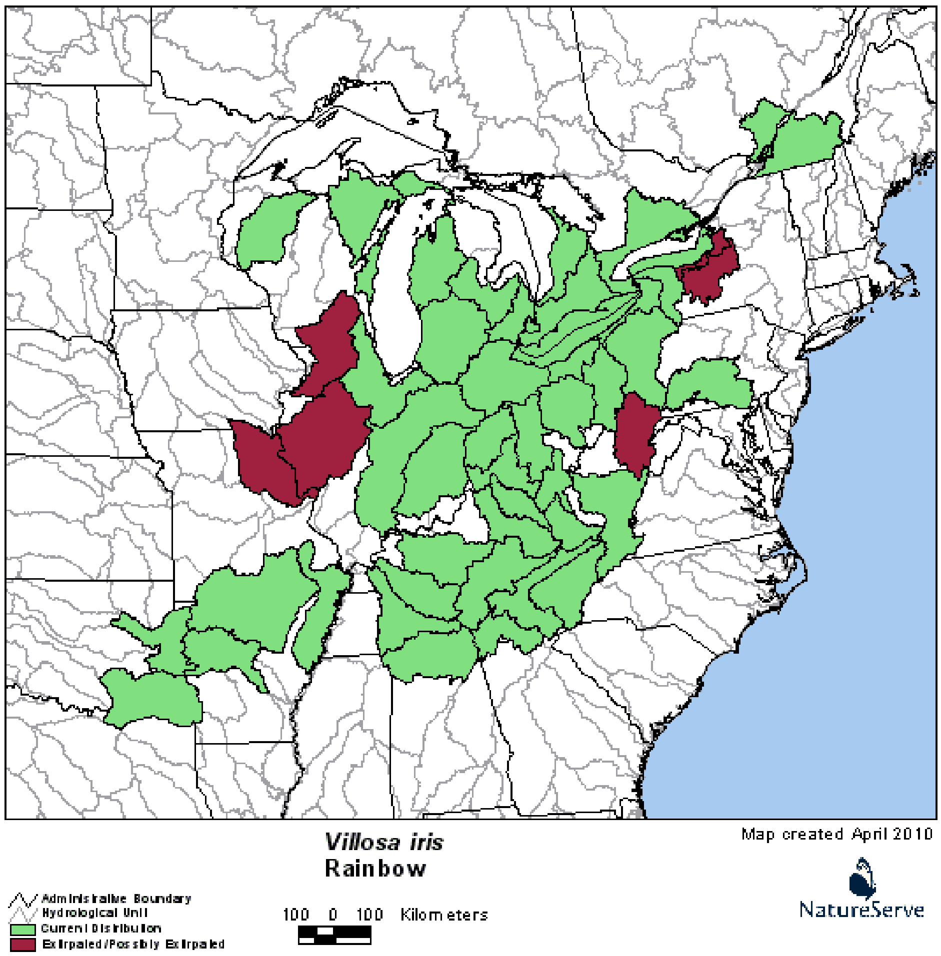

Figure 1. *V.iris* distribution in North America (NatureServe 2013). NatureServe map for New York is incorrect. Live specimens have been found in both the Oswego and the Mid Lake Ontario basins (Mahar and Landry 2013).

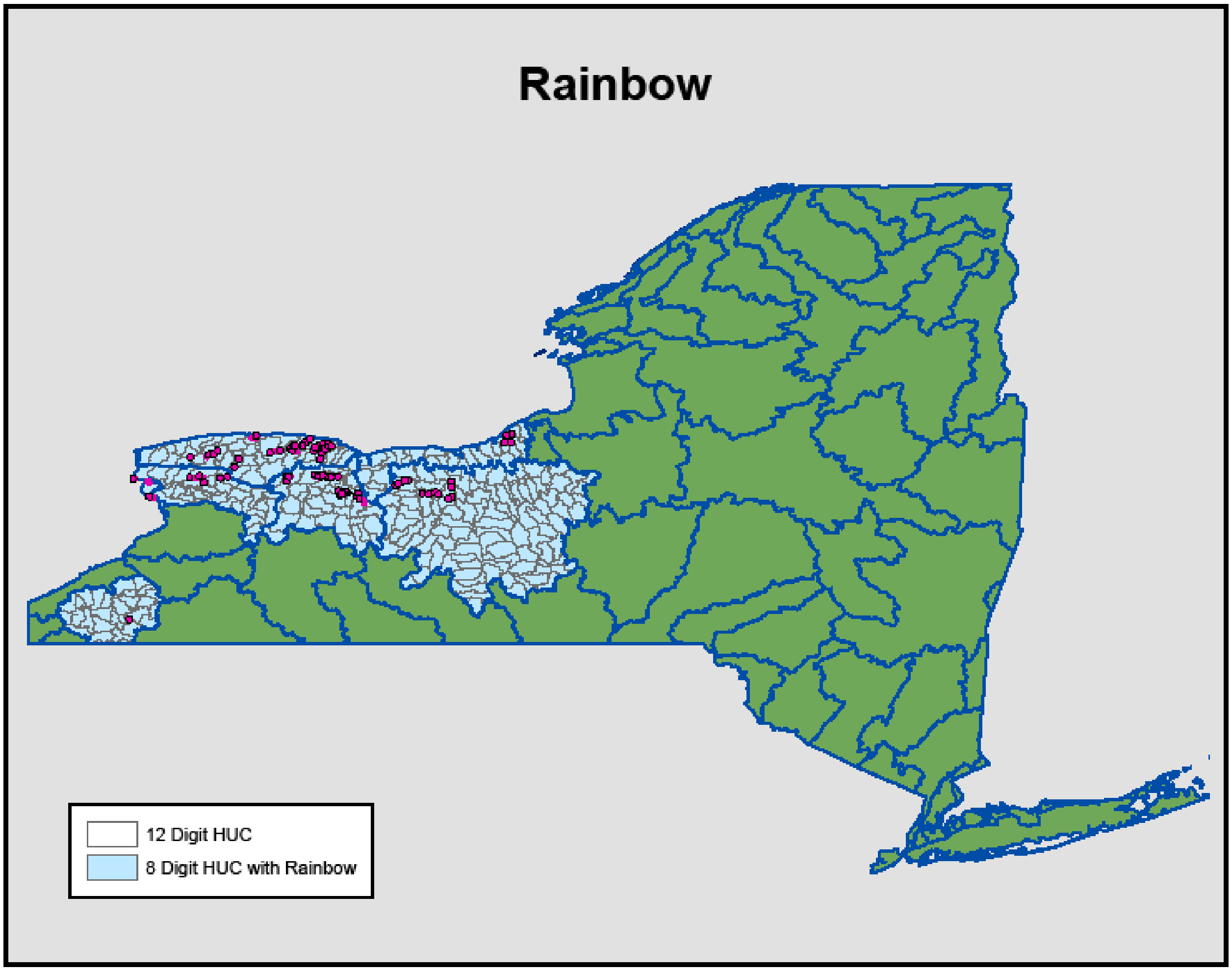

Figure 2. *V. iris* post 1970 distribution in New York (Mahar and Landry 2013, Harman and Lord 2010, The Nature Conservancy 2009, New York Natural Heritage Program 2013, White et al. 2011).

III. New York Rarity, if known:

Historic	# of Animals	# of Locations	% of State
prior to 1970	unknown	~ 20 waterbodies	~ 6 of 56 HUC 8 watersheds
prior to 1980	________	________	________
prior to 1990	________	________	________

Details of historic occurrence:

In New York, rainbow has historically been found in the Erie-Niagara, lower Genesee, and Oswego basins, as well as in several small tributaries of southern basin of Lake Ontario. It has been found in Canandaigua, Seneca, Cayuga and Oneida Lakes, as well as the Niagara, Seneca and Oswego Rivers (Strayer and Jirka, 1997). In New York's Allegheny basin, it has been found only in the "outlet of

Chautauqua Lake," and it is infrequent in the upper Allegheny basin in Pennsylvania. A single, indefinite record from the Mohawk River shows that *V. iris* may have used the Erie Canal to cross the Alleghenian Divide (Strayer and Jirka, 1997).

Current	# of Animals	# of Locations	% of State
	~424 live	27 waterbodies	6 of 56 HUC 8 Watersheds

Details of current occurrence:

Since 1970, *V. iris* has been found in 27 New York State waterbodies (Figure 2).

As part of the Southern Lake Ontario mussel inventory, 423 live *V. iris* have been found to date (Mahar and Landry 2013). In the Lower Genesee basin, *V. iris* has been found in Honeoye Creek, Black Creek, and Black Creek's tributaries: Bigelow, Onion, and Spring Creeks. In the Oswego basin, this species has been found in both Canandaigua Outlet and Ganargua Creek. *V. iris* has been found in tributaries to Lake Ontario including East Branch of Eighteenmile Creek, Johnson Creek, Oak Orchard Creek, Sandy Creek, West Branch of Sandy Creek, East Branch of Sandy Creek, Moorman Creek, West Creek, Brockport Creek, Salmon Creek, Allen Creek, Sterling Creek, Sterling Valley Creek, and Ninemile Creek.

In the Erie basin, *V. iris* shells have been found in Tonawanda Creek and its tributary Beeman Creek (Mahar and Landry, 2013). Shells were found at six additional sites and live at a single site in the Tonawanda Creek basin (Marangelo and Strayer 2000). Fresh shells have been found in the Niagara River (NY Natural Heritage Program 2013).

Shells have also been found in the Erie Canal at Lyons (Mahar and Landry 2013). *V. iris* has been reported in the Grass River basin in northern New York, the first report of the species from this basin (Strayer and Jirka 1997). *V. iris* was not found in recent surveys of the Allegheny (The Nature Conservancy 2009) or Susquehanna basins (Harman and Lord 2010). However, recent NY Natural Heritage Program records show an element of occurrence for this species in Conewango Creek in the Allegheny basin. Strayer and Jirka (1997) note that in the parts of its New York range that have been recently surveyed, *V. iris* is still relatively common.

Waterbodies with greatest *V. iris* abundance include Honeoye Creek with 162 live, East Branch Eighteenmile with 65 live, and West Creek with 61 live individuals found during recent surveys (Mahar and Landry 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	**__500 miles___**

IV. Primary Habitat or Community Type:

1. Medium River; Moderate-High Gradient; Assume Moderately Buffered (Size 3+ rivers); Warm
2. Headwater/Creek; Low-Moderate Gradient; Moderately Buffered, Neutral; Transitional Cool
3. Small River; Moderate-High 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:
V.iris is typically thought of as a species of creeks and small rivers (Cummings and Mayer 1992, McMurray et al. 2012, Metcalfe-Smith et al. 2005, Strayer and Jirka 1997, Watters et al. 2009), however it also occurs in lakes (e.g. Canandaigua, Seneca, Cayuga, Oneida) and large rivers as well (e.g. Niagara, Seneca, Oswego) (COSEWIC 2006, NatureServe 2013, Strayer and Jirka 1997, Watters et al. 2009). It is often fairly abundant (Strayer and Jirka 1997).

This species is most commonly found in sandy cobble (Watters et al. 2009), coarse sand or gravel substrates (Cummings and Mayer 1992, McMurray et al. 2012, Metcalfe-Smith et al. 2005), in or near riffles and along the edges of emergent vegetation in moderate to strong current (Metcalfe-Smith et al. 2005, Parmalee and Bogan, 1998). It becomes most numerous in clean, well-oxygenated stretches at depths of less than three feet (Parmalee and Bogan 1998).

This species is considered a habitat specialist (NatureServe 2013).

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, *V. iris* 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).

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 sited in NatureServe 2013).

It 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 with this strategy 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).

V.iris may reach approximately 15 years of age. The species is thought to be bradytictic, with gravid females reported from September to the following May (Watters et al. 2009). This species appears to be a host generalist. Glochidia have been found to transform on rock bass (*Ambloplites rupestris*), mottled sculpin *(Cottus bairdi),* streamline chub *(Erimystax dissimilis)*, greenside darter *(Etheostoma blennioides*), rainbow darter *(Etheostoma caeruleum*), bluebreast darter *(Etheostoma camurum*), green sunfish *(Lepomis cyanellus*), striped shiner *(Luxilus chrysocephalus*), smallmouth bass *(Micropterus dolomieu*), largemouth bass *(Micropterus salmoides*), and yellow perch *(Perca flavescens*) (Watters et al. 2009).

VI. Threats:

Agricultural Runoff

New York's southern Lake Ontario basin hosts the majority of the state's *V. iris* populations. Within this region, the majority of land use adjacent to *V. iris* streams is agriculture, including cultivated cropland or pasture/hay cultivation (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 run-off 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).

Treated Waste Water

At least eight streams with populations of *V. iris* receive effluent from wastewater/sewage treatment plants either directly or through nearby tributaries. These include Oak Orchard (at Medina), Johnson Creek (at Lyndonville), West Branch of Sandy Creek (at Albion), East Branch of Sandy Creek (at Holly), Black Creek (at South Byron, Bergen, and North Byron), Honeoye Creek (at Honeoye Falls, Honeoye, and Lima), Ganargua Creek (at Farmington and Victor), and Canandaigua Outlet (at Shortsville, Phelps, and Clifton Springs) (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 present in municipal sewage effluents and are increasingly 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.

Runoff from Developed Land

All New York populations of *V. iris* are found in streams that are intermittently bordered by interstate highways, state routes, and/or local roads (New York State Landcover 2010). These sites are likely threatened by 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; Liquori and Insler 1985, 2009; 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)

Habitat Modifications

Ecosystem modifications, such as isolated occurrences of canal dredging, instream work associated with bridge replacement, and vegetation 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). Since this species has been found in 27 waterbodies, such work, while devastating to individual populations, would not be expected to impact the species throughout its New York state range. Although limited in geographic scope these habitat modification activities have long term impacts on mussels and their distribution (Aldridge 2000).

Lamprey Control

V. iris populations are found in several stream that are regularly scheduled for sea lamprey control treatment. These streams include Ninemile Creek, Sterling Creek, andSandy Creek in the Lake Ontario drainage.

In New York, tributaries harboring larval sea lamprey (*Petromyzon marinus*), are treated periodically with lampricides (TFM or TFM/Niclosamide mixtures) by Fisheries and Oceans Canada and the U.S. Fish and Wildlife Service to reduce larval populations (Sullivan and Adair 2014). Niclosamide was originally developed as a molluscicide. While unionid mortality is thought to be minimal at TFM concentrations typically applied to streams to control sea lamprey larvae (1.0 –1.5 × sea lamprey MLC), increases in unionid mortality were observed when exposed to the niclosamide mixture, indicating that mussels may be at risk when the mixture is used in control operations. Treatment managers should use caution when using the combination of TFM and niclosamide in streams with known mussel populations and every effort should be made to maintain lampricide concentrations at or near the MLC for sea lamprey to minimize the risk to this important faunal group (Boogaard 2006).

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 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.

Outside of New York, the greatest threats occur in the Great Lakes portion of the range. This species has been lost from the lower Great Lakes and connecting channels largely due to impacts of the zebra mussel. Heavy loadings of sediment, nutrients and toxic substances from urban and agricultural sources have degraded mussel habitat throughout southern Ontario. *V. iris* is particularly sensitive to copper and ammonia (NatureServe 2013). Ammonia from Asian clam (*Corbicula fluminea*) die offs has been shown to be capable of exceeding acute effect levels of some mussel species, including *V. iris* (Cherry et al. 2005).

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). 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 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:

- Priority conservation efforts for this species should focus on, but not be limited to, Honeoye Creek, East Branch Eighteenmile Creek, and West Creek (Mahar and Landry 2013).
- 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 and Tank 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).

- Establish a protocol whereas DEC staff work closely with state and local highway departments to reduce impacts to native mussels during maintenance and construction projects.

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

- Within the Great Lakes and Champlain watersheds, lamprey control efforts should consider specific, potentially adverse, impacts to native freshwater mussels when determining methods, including selection of lampricide formulations and concentrations.

  Lampricide treatment managers should use caution when using the combination of TFM and niclosamide in streams with known mussel populations and every effort should be made to maintain lampricide concentrations at or near the MLC for sea lamprey to minimize the risk to this important faunal group (Boogaard 2006).

- 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.

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

Aldridge, D. C. (2000). The impacts of dredging and weed cutting on a population of freshwater mussels (Bivalvia: Unionidae). *Biological Conservation*, *95*(3), 247-257.

Anderson, K. B., Sparks, R. E., and Paparo, A. A. (1978). Rapid assessment of water quality, using the fingernail clam, *Musculium transversum*.: Final Report. University of Illinois, Urbana. 130p.

Boogaard, Michael A., *Acute Toxicity of the Lampricides TFM and Niclosamide to Three Species of Unionid Mussels,* USGS Open-File Report 2006-1106, April 2006.

Bringolf, R. B., Cope, W. G., Eads, C. B., Lazaro, P. R., Barnhart, M. C., and Shea, D. (2007). Acute and chronic toxicity of technical-grade pesticides to glochidia and juveniles of freshwater mussels (unionidae). *Environmental Toxicology and Chemistry*, *26*(10), 2086-2093.

Bringolf, R. B., Cope, W. G., Barnhart, M. C., Mosher, S., Lazaro, P. R., and Shea, D. (2007). Acute and chronic toxicity of pesticide formulations (atrazine, chlorpyrifos, and permethrin) to glochidia and juveniles of *Lampsilis siliquoidea*. *Environmental Toxicology and Chemistry*, *26*(10), 2101-2107.

Cherry, D. S., Scheller, J. L., Cooper, N. L., and Bidwell, J. R. (2005). Potential effects of Asian clam (*Corbicula fluminea*) die-offs on native freshwater mussels (Unionidae) I: water-column ammonia levels and ammonia toxicity. Journal of the North American Benthological Society 24(2):369-380.

COSEWIC (2006). *Aquatic Species at Risk - The Rainbow... a Species at Risk*. Retrieved from http://www.dfo-mpo.gc.ca/species-especes/species-especes/rainbow-villeuseirisee-eng.htm

Cummings, K. S., and Mayer, C. A. (1992). *Field guide to freshwater mussels of the Midwest* (p. 194). Champaign, Illinois: Illinois Natural History Survey.

Flynn, K., and Spellman, T. (2009). Environmental levels of atrazine decrease spatial aggregation in the freshwater mussel, *Elliptio complanata*. *Ecotoxicology and Environmental Safety*, *72*(4), 1228-1233.

Graf, D. and K. Cummings. (2011). MUSSELp Evolution: North American Freshwater Mussels. The MUSSEL Project. The University of Wisconsin. http://mussel-project.uwsp.edu/evol/intro/north_america.html

Gagné, F., Bouchard, B., André, C., Farcy, E., and Fournier, M. (2011). Evidence of feminization in wild *Elliptio complanata* mussels in the receiving waters downstream of a municipal effluent outfall. *Comparative Biochemistry and Physiology Part C: Toxicology and Pharmacology*, *153*(1), 99-106.

Gillis, P. L. (2012). Cumulative impacts of urban runoff and municipal wastewater effluents on wild freshwater mussels (*Lasmigona costata*). *Science of the Total Environment*, *431*, 348-356.

Goudraeu, S. E., Neves, R. J., and Sheehan, R. J. (1993). Effects of wastewater treatment plant effluents on freshwater mollusks in the upper Clinch River, Virginia, USA. *Hydrobiologia*, *252*(3), 211-230.

Haag, W. R. (2012). *North American freshwater mussels: natural history, ecology, and conservation*. Cambridge University Press.

Harman, W.N. and P.H. Lord (2010). Susquehanna Freshwater Mussel Surveys, 2008-2010. Final report submitted to New York State Department of Environmental Conservation. SUNY Oneonta. Cooperstown, NY. 24 pp, plus appendix.

Huebner, J. D., and Pynnönen, K. S. (1992). Viability of glochidia of two species of Anodonta exposed to low pH and selected metals. *Canadian Journal of Zoology*, *70*(12), 2348-2355.

Keller, A. E., and Zam, S. G. (1991). The acute toxicity of selected metals to the freshwater mussel, Anodonta imbecilis. *Environmental Toxicology and Chemistry*, *10*(4), 539-546.

Liquori, V. M., and Insler, G. D. (1985). Gill parasites of the white perch: Phenologies in the lower Hudson River. *New York Fish and Game Journal*, *32*(1), 71-76.

Mahar, A.M. and J.A. Landry. (2013). State Wildlife Grants Final Report: Inventory of Freshwater Mussels in New York's Southeast and Southwest Lake Ontario Basins, 2008-2013. New York State Department of Environmental Conservation. Avon, NY. *In progress*.

Marangelo, P. J., and Strayer, D. L. (2000). The freshwater mussels of the Tonawanda Creek basin in western New York. *Walkerana*, *11*(25), 97-106.

McMurray, S.E., Faiman, J.S., Roberts, A., Simmons, B., and Barnhart, C.M. 2012. *A guide to Missouri's freshwater mussels.* Missouri Department of Conservation, Jefferson City, Missouri.

Metcalfe-Smith, J., A. MacKenzie, I. Carmichael, and D. McGoldrick. 2005. Photo Field Guide to the Freshwater Mussels of Ontario. St. Thomas Field Naturalist Club. St. Thomas, ON, 60pp.

Natural Heritage Program Element Occurrences [ARC/INFO coverages] (2013). New York Natural Heritage Program, Albany, NY. Available: NYS Department of Environmental Conservation Master Habitat Data Bank's Data Selector.

NatureServe. (2013). NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: February 12, 2013).

New York State Department of Environmental Conservation. (2006). *New York State Comprehensive Wildlife Conservation Strategy*. Albany, NY: New York State Department of Environmental Conservation.

New York State Landcover, Version 1. [SDE raster digital data] (2010). National Gap Analysis Program. Moscow, Idaho. Available: NYS Department of Environmental Conservation Master Habitat Data Bank's Data Selector.

Northeastern Aquatic Habitat Classification System (NAHCS) GIS map for streams and rivers, [vector digital data] (2010). US Environmental Protection Agency, the US Geological Survey, and The Nature Conservancy Eastern Conservation Science. Boston, MA. Available: NYS Department of Environmental Conservation Master Habitat Data Bank's Data Selector.

Pandolfo, T. J., Cope, W. G., Young, G. B., Jones, J. W., Hua, D., and Lingenfelser, S. F. (2012). Acute effects of road salts and associated cyanide compounds on the early life stages of the unionid mussel Villosa iris. *Environmental Toxicology and Chemistry*, *31*(8), 1801-1806.

Parmalee, P.W. and A.E. Bogan. 1998. The Freshwater Mussels of Tennessee. University of Tennessee Press: Knoxville, Tennessee. 328 pp.

Roley, S.S. 2012. The influence of floodplain restoration on stream ecosystem function in an agricultural landscape. (unpublished doctoral dissertation). University of Notre Dame, Notre Dame, Indiana. Submitted for publishing with Tank, J.L.

Roley, S. S., J. Tank, and M. A. Williams (2012), Hydrologic connectivity increases denitrification in the hyporheic zone and restored floodplains of an agricultural stream, *J. Geophys. Res.*

Stansbery, D. H., and King, C. C. (1983). Management of Muskingum River mussel (unionid mollusk) populations. Final Report to the U.S. Department of Commerce, National Marine Fisheries

Service, and the Division of Wildlife, Ohio Department of Natural Resources. *Ohio State University Museum of Zoology Reports*. 79 p.

State Pollutant Discharge Elimination System (SPDES)- New York State [vector digital data]. (2007). Albany, New York: New York State Department of Environmental Conservation. Available: http://gis.ny.gov/gisdata/inventories/details.cfm?dsid=1010&nysgis=

Stein, B. A., Kutner, L. S., Hammerson, G. A., Master, L. L., and Morse, L. E. 2000. State of the states: geographic patterns of diversity, rarity, and endemism. *Precious heritage: the status of biodiversity in the United States. Oxford University Press, New York*, 119-158.

Strayer, D.L. and K.J. Jirka. (1997). The Pearly Mussels of New York State. New York State Museum Memoir (26): 113 pp., 27 pls.

Strayer,D.L. and Malcom, H.M. (2012). Causes of recruitment failure in freshwater mussel populations in southeastern New York. Ecological Applications 22:1780–1790

Sullivan, P. and R. Adair. 2014. Sea Lamprey Control in Lake Ontario 2013: Report to Great Lakes Fishery Commission Lake Ontario Committee Annual Meeting. Windsor, Ontario, March 26-27, 2014. Fisheries and Oceans Canada and U.S. Fish and Wildlife Service, 1-15.

The Nature Conservancy (2009). Freshwater Mussel (Unionidae) Distributions, Catches, and Measures of their Viability across the Catches, and Measures of their Viability across the Allegheny River Basin in New York. Report submitted New York State Department of Environmental Conservation. The Nature Conservancy, Central and Western NY Chapter. Rochester, NY. 63 pp.

Vaughn, C. C. and Taylor, C. M. (1999), Impoundments and the Decline of Freshwater Mussels: a Case Study of an Extinction Gradient. *Conservation Biology*, 13: 912–920.

Wang, N., Mebane, C. A., Kunz, J. L., Ingersoll, C. G., Brumbaugh, W. G., Santore, R. C., and Arnold, W. (2011). Influence of dissolved organic carbon on toxicity of copper to a unionid mussel (Villosa iris) and a cladoceran (Ceriodaphnia dubia) in acute and chronic water exposures. *Environmental Toxicology and Chemistry*, *30*(9), 2115-2125.

Watters, G. T., Hoggarth, M. A., and Stansbery, D. H. (2009). *The freshwater mussels of Ohio*. Columbus: Ohio State University Press.

White, E.L., J.J. Schmid, T.G. Howard, M.D. Schlesinger, and A.L. Feldmann. 2011. New York State freshwater conservation blueprint project, phases I and II: Freshwater systems, species, and viability metrics. New York Natural Heritage Program, The Nature Conservancy. Albany, NY. 85 pp. plus appendix.

Wildenberg, A. (2012, August). Mussel Community Response to Wastewater Effluent in a Midwestern River. In *AFS 142nd Annual Meeting*. AFS.

Williams, J.D., M.L. Warren, K.S. Cummings, J.L .Harris and R.J. Neves. 1993. Conservation status of freshwater mussels of the United States and Canada. Fisheries. 18(9):6-22.

Date last revised: _____February 26, 2014 ___________________________________