Species Status Assessment

Class: **Bivalvia**
Family: **Margaritiferiae**
Scientific Name: ***Margaritifera margaritifera***
Common Name: **Eastern pearlshell**

Species synopsis:

Margaritifera margaritifera, meaning pearl-bearer, is aptly named as this species has been fished for pearls at least since Roman times. *M. margaritifera* is North America's only native freshwater mussel whose range extends beyond the continent, occurring in New England and the Canadian Maritime Provinces, from eastern Pennsylvania to Newfoundland, Labrador, and Nova Scotia, as well as in northern Europe and Asia, from Spain, the British Isles, and Scandinavia, through central Europe to northern Asia and Japan (Strayer & Jirka, 1997; Watters et al., 2009). Since 1970, *M. margaritifera* has been documented in 24 New York State waterbodies. It is also the only member of the family *Margaritiferidae* in New York, and its biology and distribution are unique among the state's unionoids. It uses salmonids as hosts and typically lives in cold, calcium-poor waters where it is often the only unionoid species present (Strayer & Jirka, 1997).

Although not common, and ranked as "Imperiled" in New York, this edge of range species is considered "Apparently secure" throughout its range. 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** _____None - Species of Greatest Conservation Need__________

b. Natural Heritage Program Rank

i. **Global** ___G4 – Apparently Secure___________________________________

ii. **New York** ___S2 - Imperiled_____ **Tracked by NYNHP?** ____Yes______

Other Rank:

IUCN Red List Category: Endangered
American Fisheries Society Status: Special Concern (1993)

Status Discussion:

M. margaritifera has a very large distribution with some very large healthy populations remaining in North America and in some parts of Europe. It has suffered significant widespread declines in occupancy, range extent, and number of occurrence across its entire range in Europe, including several national extirpations. Declines in the U.S. and Canada have been less serious (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: SU- Special Concern SGCN? No

MASSACHUSETTS Not Present ______ No data ______

i. Abundance

__X__ declining ____increasing ____stable ____unknown

ii. Distribution:

__X__ declining ____increasing ____stable ____unknown

Time frame considered: ____________________
Listing Status: SNR SGCN? No

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

i. **Abundance**

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

ii. **Distribution:**

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

Time frame considered: ____1970-present______________________________
Listing Status: ___SX____ SGCN? __________

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: __ ____
Listing Status: ____S1 - Endangered___________________________ SGCN? ___Yes___

QUEBEC **Not Present** _________ **No data** _______

i. **Abundance**

____ **declining** ____**increasing** _____**stable** ____**unknown**

ii. **Distribution:**

____ **declining** ____**increasing** ______**stable** ____**unknown**

Time frame considered: ____
Listing Status: ____S3_____ ____

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

i. **Abundance**

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

ii. **Distribution:**

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

Time frame considered: ______________________________

Listing Status: __S2 - 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: ______________________________

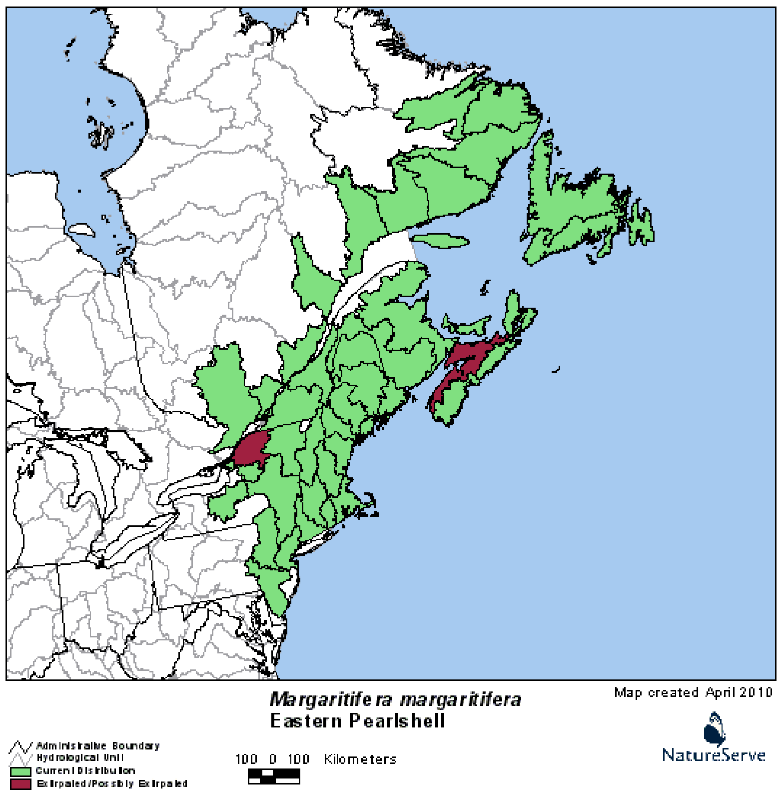
Monitoring in New York.

None

Trends Discussion:

Because these animals are so long-lived, it would be difficult to detect trends in population abundance without long-term monitoring. 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. *M. margaritifera* distribution in North America (NatureServe, 2013).



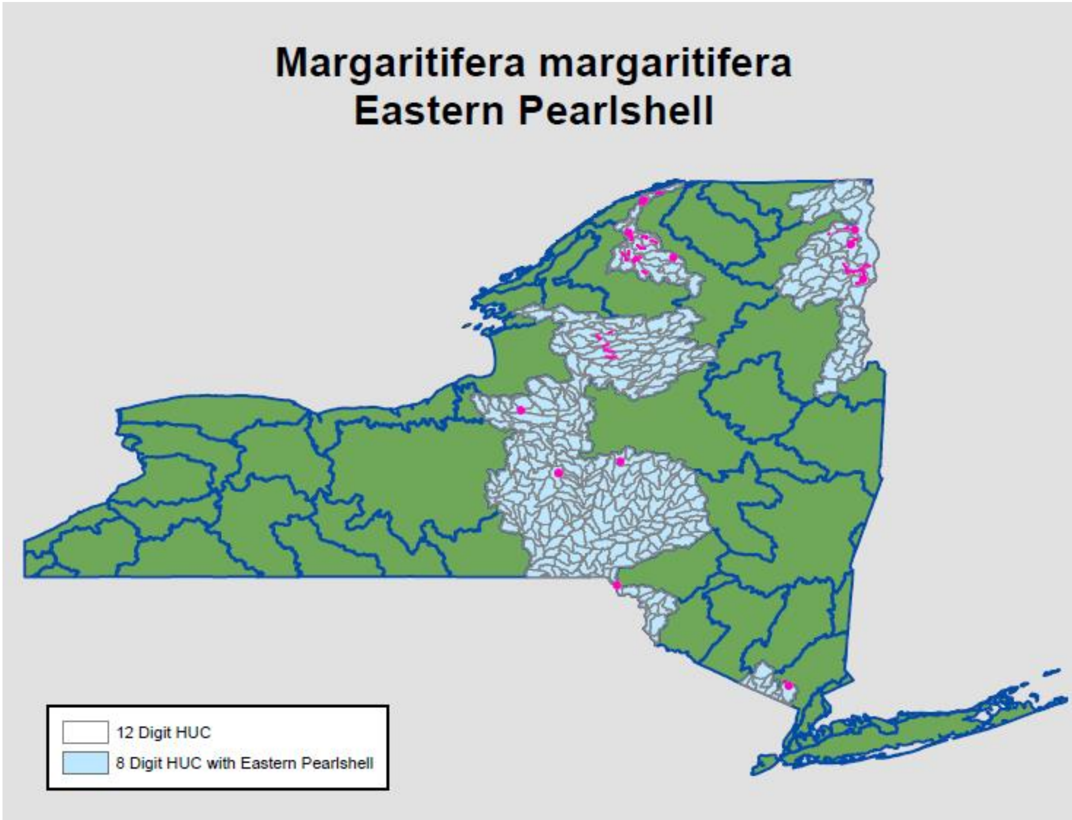


Figure 2. Post-1970 distribution of *M. margaritifera* in New York (The Nature Conservancy 2009, Harman and Lord 2010, White et al. 2011, Mahar and Landry 2013, New York Natural Heritage Program 2013).

III. New York Rarity, if known:

Historic	# of Animals	# of Locations	% of State
prior to 1970	_Unknown__	_Unknown__	_5 of 56 HUC 8 watersheds_
prior to 1980	________	________	________
prior to 1990	________	________	________

Details of historic occurrence:

M. margaritifera was historically found in the St. Lawrence River's Grass River basin, and in the Lake Champlain basin in the Saranac River and the Boquet River. It may also have occurred in the Hudson basin in the southern Adirondacks. In the 1950s, it was known to live in the upper Hackensack River basin. A single shell taken from Silver Lake (Sullivan County) in 1949 establishes its presence in the Delaware basin in New York (Strayer & Jirka, 1997).

Current	# of Animals	# of Locations	% of State
	_Unknown__	_24 waterbodies_	9 of 56 HUC8 watersheds

Details of current occurrence:

Since 1970, *M. margaritifera* has been documented in 24 New York State waterbodies (Figure 2). *M. margaritifera* is probably widespread along the margins of the Adirondacks and throughout eastern New York in nutrient-poor, soft water trout streams (Strayer & Jirka, 1997). In the mid 1990s this species was confirmed in the Grass River and its tributaries including Grannis Brook, Leonard Brook, Little River, Black Brook, Plumb Brook, the North Branch of the Grass River, and Elm Creek (NY Natural Heritage Program, 2013). Since the 1970s, this species has been found in the Black River and its tributaries including Butler Creek, Black Creek, Otter Creek, Fish Creek, and an unnamed tributary (NY Natural Heritage Program, 2013; White et al., 2011); and in Fish Creek and Scriba Creek, tributaries to Oneida (Strayer & Jirka, 1997; NY Natural Heritage Program, 2013; Mahar & Landry, 2013). In the Lake Champlain Valley, it is still found in Dry Mill Brook, the Boquet River, the North Branch of the Boquet River, and Salmon River and its tributary Riley Brook (NY Natural Heritage Program, 2013). By 1994, the upper Hackensack River site in the lower Hudson basin had low density and no evidence of reproduction (Strayer, 1995), probably a casualty of intensive residential development of the watershed (Strayer & Jirka, 1997). A single specimen was found in the Susquehanna basin in headwaters of the East Fork of the Otselic River in 2008 (Harman & Lord, 2010).

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	____350 miles_________

M. margaritifera's core distribution is in New England and the Maritimes (Strayer & Jirka, 1997).

IV. Primary Habitat or Community Type:

1. Headwater/Creek; Moderate-High Gradient; Low Buffered, Acidic; Cold

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

3. Headwater/Creek; Low-Moderate 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? _____ Yes ______ No

Indicator Species? __X__ Yes ______ No

Habitat Discussion:

M. margaritifera lives in cold, nutrient-poor, softwater, mountain streams and small rivers that support populations of trout and salmon. It never occurs in lakes, ponds, or warm-water streams; although relict populations may exist in warm and degraded portions of streams whose thermal regime and upland landscape have been altered by human activities. Best habitats are fairly small streams that are heavily shaded by a riparian canopy, possess clean cold water with high dissolved oxygen, and have stable channels with clean, stable substrates of coarse sand, gravel, and cobble (Nedeau, 2008; NatureServe, 2013). Factors believed to limit this species are eutrophication, pH (acidity), sedimentation, and water temperature (Nedeau, 2008). These habitats often are overlooked in surveys of other mussel species (Strayer & Jirka, 1997).

M. margaritifera is rarely associated with more than a very few other mussel species (Watters et al., 2009). Bauer et al. (as cited in Watters et al., 2009) hypothesized that this species has a lower metabolism than other mussels and can utilize food-poor streams not available to other species.

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, this species 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 (COSEWIC as cited in NatureServe, 2013).

This species has an equilibrium life history strategy, characterized primarily by long life span, mostly short term brooding, low to moderate growth rate, and late maturity, with low reproductive effort and fecundity that increases slowly after maturation. This life history strategy is considered to be favored in stable, productive habitats (Haag, 2012).

M. margaritifera has the highest fecundity reported for any freshwater mussel, with upward of 17 million glochidia produced annually (Bauer 1994, 1987) and is thought to be the longest-lived invertebrate animal (NatureServe, 2013). North American specimens can live for more than 50 years, while European specimens have been known to reach a maximum age in excess of 130 years (Watters et al., Bauer, Nedeau, Ziuganov et al. as cited in NatureServe, 2013). *M. margaritifera* reaches sexual maturity at 12 to 20 years of age (Watters et al., 2009; Young & Williams, 1984; Bauer, 1987). Once mature, females reproduce for the rest of their lives, never reaching senescence (Bauer as cited in Watters et al., 2009; Young & Williams, 1984; Hastie & Young as cited in NatureServe, 2013).

Females of this species have the ability to become hermaphroditic (Bauer as cited in Nedeau, 2008, Bauer as cited in Watters et al., 2009). Hermaphroditism affords benefits when population densities are low; under such conditions, females may switch to self-fertilization to ensure that recruitment continues.

Typically, salmonids are the host fish for this species (Watters et al., 2009). For fish of northeast North America, glochidia have been found to transform on Chinook salmon (*Oncorhynchus tshawytscha*), rainbow trout (*Oncorhynchus mykiss*), Coho salmon (*Oncorynchus kisutch*), brook trout (*Salvelinus fontinalis*), brown trout, (*Salvelinus fontinalis*), and Atlantic salmon (*Salmo salar*) (Watters et al., 2009). Young and Williams (1984), however, claim rainbow trout is an unsuitable host. Females are gravid from late summer to late October (Hastie & Young as cited in Nedeau, 2008), with glochidia released from July to October. Glochidia may overwinter on the host until the following May or longer (Watters et al., 2009).

VI. Threats:

Factors believed to limit *M. margaritifera* are pH (acidity), eutrophication, sedimentation, and water temperature. New York State's populations and their habitats are exposed to these threats.

Agricultural Runoff

Although the watersheds of most of New York's *M. margaritifera* streams are mostly forested, in some areas of known populations, there are exceptions. Almost the entire main stem of Fish Creek, and both the Boquet River and the North Branch of the Boquet River run through large stretches of cultivated cropland. Grannis Brook and Leonard Brook run through extensive blocks of recently harvested forest. Many other upstream tributaries to the Grass River, including Little River, Black Brook, Elm Creek, upper reaches of Grass River, and Plum Brook, also run adjacent to multiple patches of recently harvested forest 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. For example, in Germany, deposition of sand and mud, and compaction of the streambed, reduced surface-subsurface exchange and had strongly negative effect on habitat quality and juvenile recruitment (Geist & Auerswald as cited in Nedeau, 2008). 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.

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. Bauer (as cited in Strayer & Jirka, 1997) has shown that enrichment of streams by nutrients, especially nitrate, has caused declines in *M. margaritifera* populations in Europe. Bauer (1988) demonstrated that the adult mortality rate increased as stream nitrate concentrations increased, and that juvenile recruitment declined as phosphate, calcium, and biological oxygen demand increased. 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

M. margaritifera populations in the Fish Creek at Taberg, at Grass River at Canton, and in the Boquet River at both Willsboro and Wadhams are directly exposed to treated effluent from waste water treatment facilities (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 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

Although this species is found in areas of the state that have not been heavily urbanized, local and regional roads criss-cross the North Country landscape, providing a source of non-point source pollution to adjacent waterways. In addition, a stretch of the Grass River that is known to have *M. margaritifera* runs through the municipality of Canton (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).

Habitat Modifications

Ecosystem modifications, such as in-stream work associated with canal dredging, bridge replacements, gravel mining, 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).

Acidification

Acid deposition is of particular concern to New York State because of important and sensitive ecosystems which lie immediately downwind of the largest mid-western utilities burning fossil fuels and emitting sulfur dioxide and oxides of nitrogen in North America. The Adirondacks are particularly sensitive to acidic deposition because it lacks adequate soil and bedrock buffering capacity to counter the deposited acids. In this region, acidic deposition has affected hundreds of lakes and thousands of miles of headwater streams. The diversity of life in these acidic waters has been greatly reduced ("Environmental Impacts of Acid," 2012).

M. margaritifera is very sensitive to extended durations exposed to water with a pH ≤ 5.0-5.5 Dolmen & Kleiven (as cited in Nedeau, 2008), suggest that acidification and eutrophication were responsible for the extinction of 94 percent of *M. margaritifera* in Norway). For this reason, it is possible that this species has also been lost from portions of its historic New York range. Future efforts to control urban smog during the summer season will result in some reductions, however additional nitrate reductions are needed. A recent U.S. EPA report which used computer models to predict future lake acidity reported that without additional reductions in emissions, the number of acidic Adirondack lakes will actually continue to increase ("Environmental Impacts of Acid," 2012).

Water Temperature Changes

In a recent assessment of the vulnerability of at-risk species to climate change in New York, Schesinger et al. (2011) ranked this species as "extremely vulnerable." This indicates that abundance and/or range extent within New York is extremely likely to substantially decrease or disappear by 2050. Warmer stream temperatures due to the combined effects of land use, such as removal of shaded buffers, and climate change may contribute to the loss of coldwater fisheries and *M. margaritifera* populations in some watersheds (Nedeau, 2008). Temperature induced changes in fish communities could have a profound influence on the availability of hosts for freshwater mussels. Mussels, like *M. margaritifera*, that inhabit small streams and rivers and rely on fish adapted for cooler water, such as trout species, might be most affected by climate change (Nedeau, 2008).

Sea lamprey control treatments

M. margartifera populations are found in several stream that are regularly scheduled for sea lamprey control treatment. These streams include Scriba Creek, Fish Creek, and Black River in the Lake Ontario drainage and Boquet River and Salmon River in the Lake Champlain drainage. Fish Creek, a known *M. margaritifera* stream, was treated with lampricide in 2013. The impact of this treatment on the *M. margaritifera* population has not been evaluated.

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 & 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

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. 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, 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.

- 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).

- In areas subject to tree harvest, promote best forestry practices to reduce/eliminate sedimentation and to ensure that substantial woody vegetation in areas directly adjacent to streams continue to provide temperature-moderating shade to the stream.

- 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 & 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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