Species Status Assessment

Class: **Bivalvia**
Family: **Unionidae**
Scientific Name: ***Alasmidonta heterodon***
Common Name: **Dwarf wedgemussel**

Species synopsis:

Alasmidonta heterodon 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).

Never common, *A. heterodon* is currently known from at least 70 locations in 15 major watersheds, with the largest populations in the Connecticut River watershed in New Hampshire and Vermont (Nedeau 2008). In New York, it is currently found in four waterbodies. It is the only federally endangered mussel in New England and it is listed as endangered in every state where it occurs (Nedeau 2008). *A. heterodon* lives in running waters of all sizes, from small brooks less than 5 m wide to large rivers more than 100 m wide (United Sates Fish and Wildlife Service 1993). It does not show any preference towards a certain microhabitat (Strayer 1993). This species has shown a 50% – 70% decline in abundance both in the short and long term (NatureServe 2013). It is extant in ten states and likely extirpated from Canada (Hanson and Locke 2000, Metcalfe-Smith and Cadmore-Vokey 2004) and possibly Pennsylvania and is nearly extirpated from Massachusetts and Connecticut.

Status

a. Current and Legal Protected Status

i. **Federal** ____ _ Endangered________________**Candidate?** ___No______

ii. **New York** _____Endangered – Species of Greatest Conservation Need____

b. Natural Heritage Program Rank

i. **Global** _____G1G2 – Critically Imperiled / Imperiled____________________

ii. **New York** ____ S1 – Critically Imperiled__ **Tracked by NYNHP?** __ Yes___

Other Rank:

U.S. Endangered Species Act (USESA): Listed endangered (1990)
Canadian Species at Risk Act (SARA) Schedule 1/Annexe 1 Status: XT (2003)
Committee on the Status of Endangered Wildlife in Canada (COSEWIC): Extirpated (2009)
IUCN Red List Category: Endangered
American Fisheries Society Status: Endangered (1993)

Status Discussion:

Historically, this species was widespread, though never common, along the Atlantic Slope from New Brunswick to the Carolinas. The species has experienced significant decline including the regional extirpation of the last remaining population in Canada. Of the small number of extant occurrences remaining, long-term viability is questionable given continuing declines and difficult-to-manage threats. Decline has continued, especially over the last 10 years. *A. heterodon* currently occupies only 20-25% of its historic sites, with populations severely fragmented. Declines are even more pronounced, in the southern half of its range, from New Jersey south to North Carolina with individual populations numbering only in the tens to hundreds of individuals. The species continues to face significant threats from habitat loss primarily due to human encroachment throughout its range and, without intervention, may decline to the point of critical imperilment soon (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: ____from 1960s to present (NatureServe 2013)_____

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? __________

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: __________1970 –present__________________

Listing Status: ____S1 Endangered_______________ SGCN? ____Yes______

Recent storms and flooding events have impacted known habitats. Several previously occupied areas are now unsuitable to support dwarf wedgemussel populations (Davenport 2012).

ONTARIO **Not Present** ________ **No data** ___X____

i. **Abundance**

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

ii. **Distribution:**

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

Time frame considered: ________________________________

Listing Status: ________________________________

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** __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 - Endangered________________ SGCN? __Yes________

d. NEW YORK **No data _______**

i. Abundance

__x__ declining ____increasing ____stable _____unknown

ii. Distribution:

_____ declining ____increasing __x__stable ______unknown

Time frame considered: ____

Monitoring in New York.

None

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.

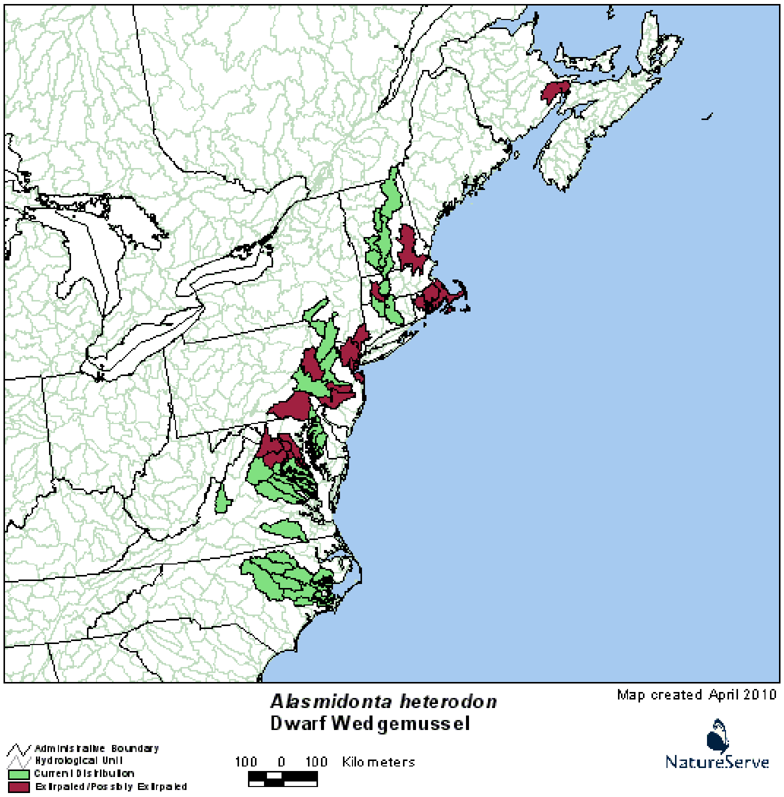

Figure 1. *A. heterodon* distribution in North America (NatureServe 2013).

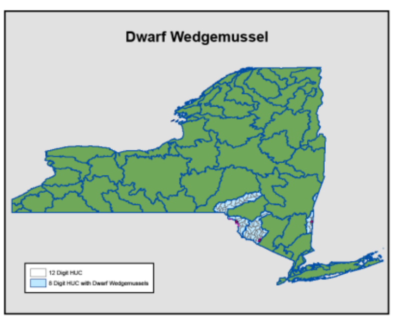

Figure 2. Post 1970 distribution of *A. heterodon* in New York (Mahar and Landry 2013, Harman and Lord 2010, The Nature Conservancy 2009, New York Natural Heritage Program 2013, White et al. 2011).

III. New York Rarity, if known:

Historic	# of Animals	# of Locations	% of State
prior to 1970	__unknown_	1 waterbody	1 of 56 HUC 8 watersheds_
prior to 1980	________	________	________
prior to 1990	________	_______	__ ___

Details of historic occurrence:

Historically, *A. heterodon* has been found only in the lower Neversink River of the Delaware basin.

Current	# of Animals	# of Locations	% of State
	> 20,000	4 waterbodies	3 of 56 HUC 8 watersheds

Details of current occurrence:

Since 1970, *A. heterodon* has been known to four waterbodies in New York State (Figure 2). It is found from a short reach of the lower Neversink River (1997) and its tributary Basher Kill (2000), where approximately 20,000 animals (Strayer et al. 1996, NY Natural Heritage Program 2013), one of the world's largest populations of this rare species, remain (Strayer and Jirka 1997). It has also been found live in the upper Delaware River as recently as 2002 and a sparse population was found in Webatuck Creek in South Amenia in 2007 (NY Natural Heritage Program 2013).

A. heterodon has been reported from the Passaic River basin in New Jersey and the Housatonic River basin in Connecticut, so it may yet turn up elsewhere in the Atlantic drainage of southeastern New York (Strayer and Jirka 1997).

New York's Contribution to Species North American Range:

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

IV. Primary Habitat or Community Type:

1. Medium River; Low Gradient; Assume Moderately Buffered (Size 3+ rivers); Warm
2. Medium River; Low Gradient; Assume Moderately Buffered (Size 3+ rivers); Transitional Cool
3. Medium River; Moderate-High Gradient; Assume Moderately Buffered (Size 3+ rivers); 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 . heterodon is a generalist in terms of its preference for stream size, substrate, and flow conditions. It does not show any strong preference for particular habitats or microhabitats and is found in a variety of substrate types including clay, sand, gravel, pebble, and often in depositional areas and banks with large amounts of silt (Nedeau 2008). Other habitats included are amongst submerged aquatic plants, and near stream banks underneath overhanging tree limbs (NatureServe 2013). It inhabits very shallow water along stream banks, but has also been found at depths of 25 feet in the

Connecticut River. They do not inhabit lakes or reservoirs, but may occur in small impoundments. Stable flow and stable substrate are critical for this species (Nedeau 2008). This species is relatively sensitive to pollution, siltation, and low dissolved oxygen (McLain and Ross 2005). In New York, *A .heterodon's* habitat is a small (40m wide), coolwater river, where it lives bedded in the fine sediments that accumulate between cobbles (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 (Watters et al. 2009). The low densities (<0.5 per square meter) in which *A. hetrodon* often occurs is problematical since females need to be in close proximity to a sperm releasing male to be successfully fertilized (Strayer et al. 1996). Eggs are fertilized within the female. Like nearly all North American mussels, *A. hetrodon* 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).

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).

The lifespan of the *A. heterodon* is considered less than 12 years. It has a lower fecundity than most other species. This species is bradytictic, with fertilization occurring in late summer and glochidia released between March and May of the following spring (Nedeau 2008).

In laboratory experiments, Michaelson and Neves (1995) indentified three fish species as possible glochicial hosts: tesselated darter (*Etheostoma olmstedti*), Johnny darter (*Etheostoma nigrum)*, and mottled sculpin (*Cottus bairdi)*. Slimy sculpin (*Cottus cognates)* (Schulz and Marbain 1998) and Atlantic salmon (*Salmo salar*) (Wicklow 1999)were also identified as a host fish. Additional potential hosts include striped bass (*Morone saxatilis*) and banded killifish (*Fundulus diaphanus*) (Nedeau 2008). Recent published work indicates that although it has multiple hosts, it prefers the tessellated darter. Darter hosts have been shown to remain close to the area where they were infested with mussel glochidia (order of meters) indicating low dispersal capability (McLain and Ross, 2005; Strayer et al. 2006).

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 2009). Tesselated darters usually move less than 100 meters during their lives, thus the dispersal ability of *A. heterodon* is low and the rate at which they might re-colonize former habitat is slow (McLain and Ross 2005).

Short life spans, low fecundity, high degree of host specificity, limited dispersal ability of most of its host species, and low population densities contribute to the endangered status of the *A. heterodon* (Nedeau 2008).

VI. Threats:

Agricultural Runoff

Although land use in the Delaware basin is primarily forest, several areas of cultivated cropland are found immediately adjacent to both *A. heterodon* occurrences on Neversink River and to the two southernmost occurrences on the Delaware River between Callicoon and Cochectcon. In addition, extensive agriculture (pasture, hay, and cultivated cropland) borders *A. heterodon* habitat on Webatuck Creek (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

Treated waste water effluent enters the Delaware River near *A. heterodon* occurrences at Callicoon (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

Residential development is present adjacent to *A. heterodon* habitat on Neversink at Myers Grove. And although the Delaware watershed is mostly forested both a railroad and roads runs adjacent to the Delaware River (Rte 97 and local roads). In addition, in the stretch where *A. heterodon* have been found, there are multiple patches of developed land. This is especially true at Long Eddie, Hankins, and Callicoon (New York State Landcover 2010). These developed lands are likely sources of runoff containing metals and road salts. 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 as cited in Watters et al. 2009), 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; 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).

Invasives

Didymo (*Didymosphenia geminata*), a filamentous diatom, can form extensive mats that can smother stream bottoms and occlude habitat for mussels (Spaulding and Elwell, 2007). 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. heterodon* populations (Nedeau 2008).

Range wide, competition with exotic bivalves, both the Asian clam (*Corbicula fluminea*) and zebra mussel (*Dreissena polymorpha*) could pose a threat because these exotics are expected to eventually invade many Atlantic slope watersheds (NatureServe 2013).

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 *A. heterodon* 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 *A. heterodon*, that inhabit small streams and rivers and rely on fish adapted for cooler water, such as several species of sculpins, darters, and salmonids, might be most affected by factors such as climate change or the removal of shaded buffers (Nedeau 2008).

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.

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

Section 7(a) of the Federal Endangered Species Act, as amended, requires Federal agencies to evaluate their actions with respect to any species that is proposed or listed as Federally endangered or threatened. Regulations implementing this interagency cooperation provision of the Act are codified at 50 CFR Part 402. Section 7(a)(4) requires Federal agencies to confer informally with the Service on any action that is likely to jeopardize the continued existence of a proposed species or result in destruction or adverse modification of proposed critical habitat. If a species is listed subsequently, Section 7(a)(2) requires Federal agencies to ensure that any activities they authorize, fund, or carry out are not likely to jeopardize the continued existence of such a species or to destroy or adversely modify its critical habitat. If a Federal action may affect a listed species or its critical habitat, the responsible Federal agency must enter into formal consultation with the Service.

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 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.
- All populations should receive protection through acquisition, easements, registry, and/or working with local, state, and federal government agencies on issues relating to zoning and streamside development, water quality, regulation of water flows, land use practices, etc (NatureServe 2013).
- 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.

- Priority conservation efforts for this federally listed species should focus on any New York stream in the species occurs, especially the Neversink River and the Basherkill.

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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