Species Status Assessment

Class: **Bivalvia**
Family: **Unionidae**
Scientific Name: ***Utterbackia imbecillis***
Common Name: **Paper pondshell**

Species synopsis:

Utterbackia imbecillis 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 one likely extirpated New York species of the genera Alasmidonta, Anodonta, Anodontoides, Lasmigona, Pyganodon, Simpsonaias, Strophitus, and Utterbackia (Haag, 2012; Graf and Cummings, 2011). *U. imbecillis* is the only member of the *Utterbackia* genus. The species name *imbecillis* comes from the Latin word meaning feeble or weak; most likely describing the thin, fragile shell of *U. imbecillis* (Watters et al., 2009).

U. imbecillis generally prefers muddy/silty habitats with relatively slow moving water (NatureServe 2013; Watters et al., 2009). In New York this species is currently found in four streams in the Oswego and Mid-Ontario basins, and in the Erie Canal from Orleans county to Wayne county (Mahar & Landry, 2013). Historically, *U. imbecillis* was also found in the Alleghany, Mohawk, and upper Hudson basins (Strayer & Jirka, 1997). The New York state rank for *U. imbecillis* should be updated from Historic to a rank reflecting its rarity and continued presence in the state.

In North America, approximately 2/3 to ¾ of native mussel species are extinct, listed as endangered or threatened, or are in need of conservation status (Williams *et al.* 1993; Stein *et al.*2000). While population trends in New York are unknown, based on sparse historical information, it is assumed that they too are declining due to a myriad of environmental stressors.

I. 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 _____SH – Historic (Note: this is incorrect. This species was found live in NY in 2011 and 2012)_____ **Tracked by NYNHP?** ____Yes_

Other Rank:

American Fisheries Society Status: Currently Stable (1993)

Status Discussion:

This species is very widespread with many populations across much of U.S. (edge of range states less common) and also into Mexico. It is stable or increasing, and is tolerant of a wide range of habitat conditions (NatureServe, 2013). Previously considered historic in New York, it was found during surveys in 2011 and 2012.

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

____ declining ____increasing __X__stable _____unknown

ii. Distribution:

____ declining ____increasing __X___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

____ declining ____increasing ______stable __x___ unknown

ii. Distribution:

____ declining ____increasing ______stable __x___ unknown

Time frame considered: ___2003-2013______________________________________
Listing Status: _____S2____

PENNSYLVANIA **Not Present** ________ **No data** __X____

i. Abundance

____ declining ____increasing ____stable __X__unknown

ii. Distribution:

____ declining ____increasing ____stable __X__unknown

Time frame considered: ____
Listing Status: ___S3S4______________________ SGCN? ___No___

QUEBEC **Not Present** ___X___ **No data** _______

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

d. NEW YORK **No data** _______

i. Abundance

____ declining ____increasing __X__stable _____unknown

ii. Distribution:

_____ declining ____increasing __X__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 & 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.

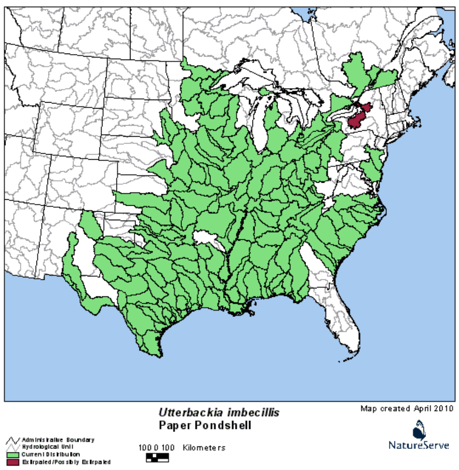

Figure 1. *U. imbecillis* distribution in North America (NatureServe, 2013). This map is incorrect, as *U. imbecillis* has recently been found live in New York's Mid Lake Ontario basin (Mahar & Landry, 2013).

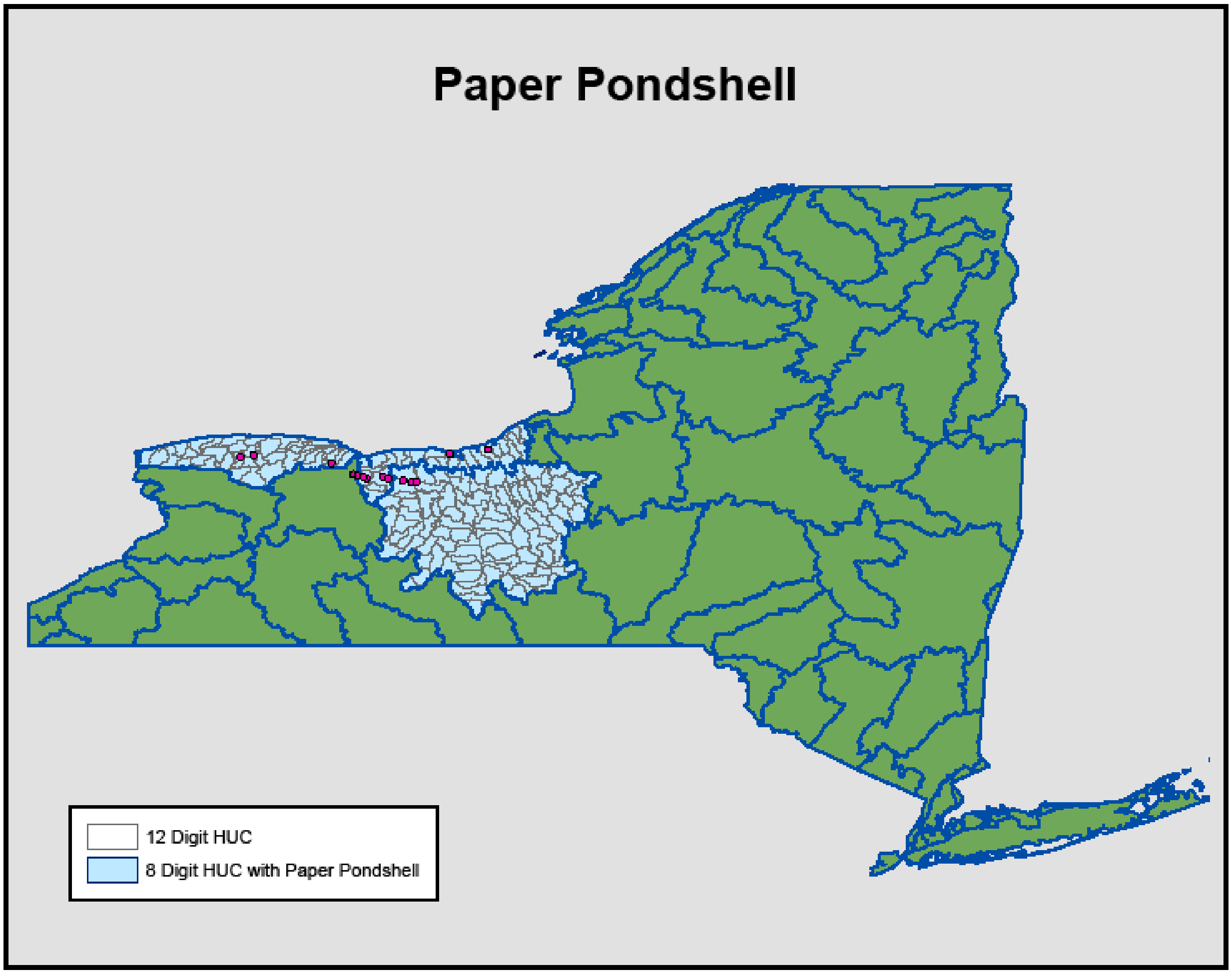

Figure 2. *U. imbecillius* post 1970 distribution in New York (Mahar & Landry, 2013; Harman and Lord, 2010; The Nature Conservancy, 2009; New York Natural Heritage Program, 2013; White et al., 2011).

III. New York Rarity, if known:

Historic	# of Animals	# of Locations	% of State
prior to 1970	11 Live	5 waterbodies	6 of 56 HUC 8 watersheds
prior to 1980	________		________
prior to 1990	________		________

Details of historic occurrence:

In New York, records for *U. imbecillis* are few and scattered. They include: Chautauqua Lake (1895) and its outlet; Erie Canal from Pittsford to Macedon (1959); Irondequoit Creek (1891); Seneca Lake near Geneva; Clyde River near Marengo, and Seneca River at the north end of Cayuga Lake (1970); Onondaga County (1887); Oswego River (1895); Mohawk River (1868); Brown's Tract Pond; and Raquette Lake (Strayer & Jirka, 1997). This distribution is remarkable for its wide extent and erratic character, which unlike distributions of other unionoids, does not closely follow drainage patterns other than the central part of the Erie Canal (Strayer & Jirka, 1997). Strayer and Jirka (1997) show no records for this species after 1970, and no positive records are found in the New York Natural Heritage Program elements of occurrence database (2013).

Current	**# of Animals**	**# of Locations**	**% of State**
	6 live	5 waterbodies	3 of 56 HUC 8 watersheds

Details of current occurrence:

Since 1970, *U. imbecilis* has been known from five New York State waterbodies (Figure 2).

In the Oswego basin, this species has been found live in Red Creek (Palmyra) and Pond Brook, an outflow of Junius Ponds, both in Wayne County, and Catharine Creek Canal in Schuyler County. In the Mid Lake Ontario basin, it has been found live in Red Creek (Wolcott) and First Creek, also both in Wayne County. A total of 57 fresh shells were found at 13 Erie Canal locations between Ridgeway, Orleans Co. and Macedon, Wayne County, with the majority of the shells (32) found at a single site in Macedon (Mahar & Landry, 2013).

No evidence of *U. imbecillis* was found in the Lower Genesee basin and the only occurrences of this species in the West Lake Ontario basin were from the Erie Canal (Mahar & Landry, 2013). This species was not detected in the recent Allegheny basin and Susquehanna basin mussel surveys (The Nature Conservancy, 2009; Harman & Lord, 2010).

Live *U. imbecillis* were found in Spicer Creek (Niagara River Tributary, Grand Island, 2 specimens) in 2011, and in Lake Ontario watershed: 2 in Twelve Mile Creek (Niagara Co.) and one in the Black River Bay in 2012 (Burlakova, Karatayev et al. unpublished data).

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	__X__ Disjunct
____ 26-50	Distance to core population:
__X__ 1-25	__500 miles____

IV. Primary Habitat or Community Type:

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

Habitat or Community Type Trend in New York:

____ Declining ____Stable __X__ Increasing __ __Unknown

Time frame of decline/increase: ______________________________

Habitat Specialist? ______ Yes ____X___ No

Indicator Species? ___X___ Yes ______ No

Habitat Discussion:

U. imbecillis is most typically found in soft substrates in quiet waters of ponds, lakes, and sluggish mud-bottomed pools and backwaters of creeks and rivers (Strayer & Jirka, 1997; Cummings & Mayers, 1992; Metcalfe-Smith et al., 2005; McMurray et al., 2012; Watters et al., 2009). It is commonly found in artificial waters (e.g., canals, impoundments, boat basins, retention ponds, old phosphate pits) (NatureServe 2013; Watters et al., 2009). This species seems to be tolerant of moderately poor water and habitat quality (muddy substrates). Such substrates have become more prevalent with increased eutrophication (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:

U. imbecillis is thought to be hermaphroditic with both gametes maturing simultaneously in the same individual. Hermaphroditism affords benefits when population densities are low; under such conditions, females may switch to self-fertilization to ensure that recruitment continues (Watters et al., 2009).

This species is also one only of 2-3 unionid species capable of direct development, meaning there is no need for a host fish, at least under certain conditions (NatureServe, 2013). Metamorphosis in the absence of host parasitism has been confirmed, although in the laboratory, fish-reared juveniles were found to be in more robust physiological condition than their counterparts that metamorphosed without a host fish (Dickinson and Sietman, 2008 and Fisher and Dicmock, 2006as cited in NatureServe, 2013).

Although this species may be able to develop without a fish host, it also can complete its life cycle in the usual way (Strayer & Jirka, 1997). *U. imbecillis* is a host generalist (Watters et al., 2009) and has more identified hosts, including three amphibians, than any other unionid (Watters et al., 2009). Known fish hosts, not including exotic aquaria fish, include: rock bass (*Ambloplites rupestris)*, spotfin shiner (*Cyprinella spiloptera*), greenthroat darter (*Etheostoma lepidum*), banded killifish (*Fundulus diaphanus*), channel catfish (*Ictalurus punctatus*), green sunfish (*Lepomis cyanellus*), pumpkinseed (*Lepomis gibbosus*), bluegill (*Lepomis macrochirus*), longear sunfish (*Lepomis megalotis*), largemouth bass (*Micropterus salmoides*), golden shiner (*Notemigonus crysoleucas*), yellow perch (*Perca flavescens*), black crappie (*Pomoxis nigromaculatus*), and creek chub

(*Semotrilus atromaculatus*) (Watters et al., 2009). Amphibian hosts include tiger salamander (*Ambystoma tigrinum*), bullfrog tadpole (*Rana catesbeiana*), and northern leopard frog tadpole (*Rana pipens*) (Watters et al., 2009). Other potential hosts include: mosquitofish (*Gambusia affinus*) and warmouth (*Lepomis gulosus*) (Watters et al., 2009).

These characteristics may make *U. imbecillis* an unusually good colonizer among unionoids and may free it to some extent from the constraint of dispersing within drainage basins (Strayer & Jirka, 1997).

This species has an opportunistic life history strategy. This strategy is often characterized by short life span, early maturity, high fecundity achieved soon after maturation, and, to a lesser extent, moderate to large body size. Species in this group have the fastest growth rates and highest reproductive effort. Nearly all opportunistic species are long-term brooders. This life history strategy is considered an adaptation for rapid colonization and persistence in disturbed and unstable but productive habitats (Haag, 2012).

U.imbecillis is a short lived species and rarely lives for more than five years. The species is bradytictic, with gravid females present from April through September in Ohio (Watters et al., 2009).

In the adult form, freshwater mussels are basically sessile; movement is limited to a few meters of 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).

VI. Threats:

Agricultural Runoff

Several streams that host *U. imbecillis* populations, including Red Creek in Wolcott, Pond Brook, and the Erie Canal, flow through heavily agricultural areas and are likely impacted by associated siltation, nutrient and pesticide loading. In addition, just upstream of the site where live specimens were found, First Creek flows through a golf course and likely receives pesticide and fertilizer runoff from this source (New York State Landcover, 2010). Aquatic habitats lacking vegetated buffers of adequate width are threatened by runoff from urban areas, roads, lawns, and agricultural land (Gillis, 2012). If best management practices are not closely adhered to, mussel habitat adjacent to wood harvest or agricultural land is subjected to pesticide, fertilizer, and silt/sediment runoff. During recent mussel surveys in western and central New York, it has been documented that sufficient vegetated riparian buffers are often lacking along known mussel streams (Mahar & Landry, 2013), indicating that runoff is a major threat to resident mussel populations.

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

Runoff from Developed Land

All five of New York waterbodies that are known to currently host *U. imbecillis* populations are intermittently bordered by an interstate highways, state routes, and/or local roads and lawns (New York State Landcover, 2010), and likely receive runoff containing metals and road salts from these sources. 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., 2007).

Treated Waste Water

Red Creek in Wolcott receives treated effluent from the village of Red Creek Regional Waste Water Treatment Plant (SPDES, 2011). It is also possible that raw sewage enters the Erie Canal from illegal dumping by recreational boats. 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 also are present in municipal sewage effluents and are increasingly common 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, Harmon & Lord (2010) found no evidence that waste water treatment plants were responsible for reductions in mussel species of greatest conservation need.

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).

Based on the number of fresh shells found, it is thought that the majority of New York's *U. imbecillis* populations reside in the Erie Canal system. Habitat modification threats present in the Erie Canal include maintenance dredging by the NY Canal Corporation and seasonal water draw downs. Seasonal draw downs of water bodies have been shown to impact unionid age distributions (Richardson et al. 2002) and it is likely that the Erie Canal water draw downs have negative impacts on the *U. imbecillis* population. During spring mussel surveys of the Erie Canal, it is not uncommon to find hundreds of fresh shells of multiple species, including *U. imbecillis,* and multiple age classes, many containing desiccating flesh, along the exposed canal banks and bed (Mahar & Landry, 2013). This antidotal evidence suggests seasonal draw downs have a large impact on these populations.

Invasive Species

Invasive zebra and quagga mussels (*Dreissena polymorpha* and *Dreissena bugenis*) have been repeatedly cited as a threat to native mussel populations (Strayer & Jirka, 1997; Watters et al., 2009). This threat is of particular concern to the *U. imbecillis* populations in the Erie Canal. En masse, Dreissenids outcompete native mussels by efficiently filtering food and oxygen from the water. They reduce reproductive success by filtering native mussel male gametes from the water column and they can foul the shells of the native mussels to the point that their valves can no longer open. In heavily invested areas, they may transform a habitat by hardening the substrate, such that dislodged mussels are not able to rebury (USFWS, 1994).

Lamprey Control

U. imbecillis populations are found in several stream that are regularly scheduled for sea lamprey control treatment. These streams include Red Creek and Catharine 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) or by NYSDEC. 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).

Aquatic Habitat Barriers

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:

- Priority conservation efforts for this species should focus on, but not be limited to, the Erie Canal, especially between Pittsford and Macedon/Palmyra (Mahar & 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 & 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.

- Enforce No Discharge Zone, and promote the proper discharge of sewage by recreational boaters on the Erie Canal.

- 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, USGS 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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