

## Species Status Assessment

**Class:** Bivalvia  
**Family:** Unionidae  
**Scientific Name:** *Lampsilis fasciola*  
**Common Name:** Wavy-rayed lampmussel

### Species synopsis:

*Lampsilis fasciola* belongs to the subfamily Ambleminae and the tribe Lampsilini, which includes 17 extant and 6 likely extirpated New York species of the genera *Actinonaias*, *Epioblasma*, *Lampsilis*, *Leptodea*, *Ligumia*, *Obovaria*, *Potamilus*, *Ptychobranhus*, *Toxolasma*, *Truncilla*, and *Villosa* (Haag, 2012; Graf and Cummings, 2011).

*L. fasciola* is mainly found in and around riffle areas of clear, hydrologically stable, fast moving water (Watters et al., 2009). Since 1970, *L. fasciola* has been found in six New York waterbodies. Historically, it has been collected in the Erie, Western Lake Ontario, and Lower Genesee basins (Strayer & Jirka, 1997). *L. fasciola* no longer considered abundant in any New York location, however they are most commonly found in the Allegheny River and its tributaries (The Nature Conservancy, 2009).

With a state rank of “critically imperiled,” *L. fasciola* is listed as threatened in New York State, although it is secure throughout its range (NatureServe, 2013). In North America, approximately  $\frac{2}{3}$  to  $\frac{3}{4}$  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 Threatened

### b. Natural Heritage Program Rank

- i. Global G5 - Secure
- ii. New York S1 - Critically imperiled Tracked by NYNHP? Yes

#### Other Rank:

Canadian Species at Risk Act (SARA) Schedule 1/Annexe 1 Status: Endangered (2003)  
Committee on the Status of Endangered Wildlife in Canada (COSEWIC): Special Concern (2010)  
American Fisheries Society Status: Currently Stable (1993)

#### Status Discussion:

The range of this species includes the Great Lakes drainage; including the tributaries of Lake Michigan, Lake Huron, Lake St. Clair, Lake Erie, Lake Huron; and the Ohio-Mississippi drainage south to the Tennessee River system, with edge of range populations (especially in Canada) experiencing slight decline (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**

\_\_\_ declining \_\_\_ increasing \_\_\_ stable  X  unknown

**ii. Distribution:**

\_\_\_ declining \_\_\_ increasing \_\_\_ stable  X  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  X  increasing \_\_\_ stable \_\_\_ unknown

**ii. Distribution:**

\_\_\_ declining  X  increasing \_\_\_ stable \_\_\_ unknown

Time frame considered:  2003-2013

Listing Status:  Federally Special Concern and Provincially Threatened

PENNSYLVANIA Not Present \_\_\_\_\_ No data \_\_\_\_\_

i. Abundance

\_\_\_\_ declining \_\_\_\_ increasing \_\_\_\_ stable **X** unknown

ii. Distribution:

\_\_\_\_ declining \_\_\_\_ increasing \_\_\_\_ stable **X** unknown

Time frame considered: \_\_\_\_\_

Listing Status: S4 SGCN? No

QUEBEC Not Present **X** No data \_\_\_\_\_

VERMONT Not Present **X** No data \_\_\_\_\_

d. NEW YORK No data \_\_\_\_\_

i. Abundance

**X** declining \_\_\_\_ increasing \_\_\_\_ stable \_\_\_\_ unknown

ii. Distribution:

**X** declining \_\_\_\_ increasing \_\_\_\_ stable \_\_\_\_ unknown

Time frame considered: \_\_\_\_\_

**Monitoring in New York:**

As part of a State Wildlife Grant, NYSDEC Region 8 Fisheries and Wildlife staff is conducting a baseline survey of tributaries in central and western New York for native freshwater mussels 2009 - 2017.

**Trends Discussion:**

Trends for New York populations are difficult to determine as most historic data comes from opportunistic naturalist collections, as opposed to more comprehensive baseline surveys. For example, mussels were documented for the first time in 50 of the 106 streams surveyed to date by

the Southern Lake Ontario mussel inventory project (Mahar & 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 3/4 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.

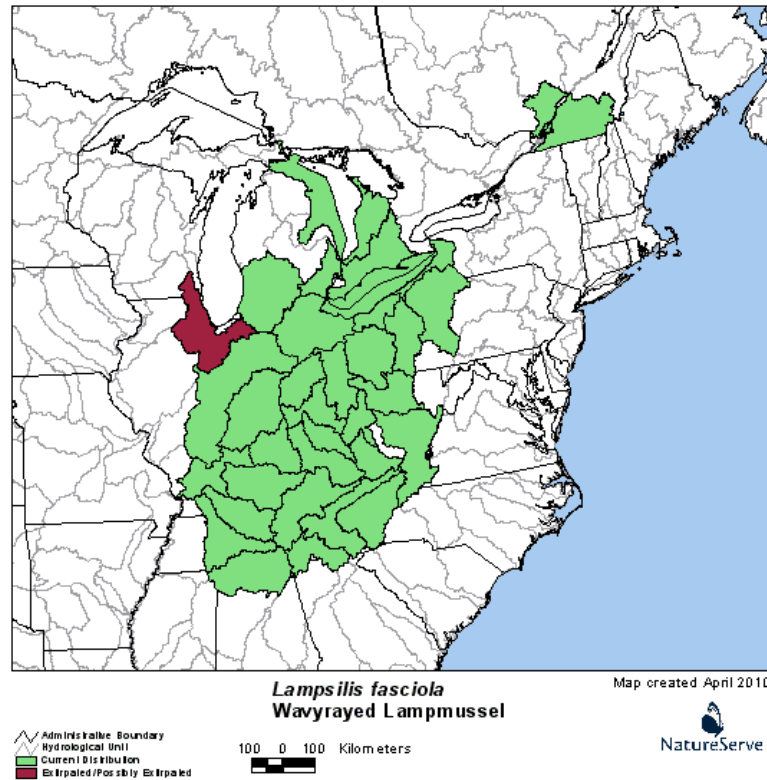


Figure 1. Range wide distribution of *L. fasciola* in North American (NatureServe 2013).

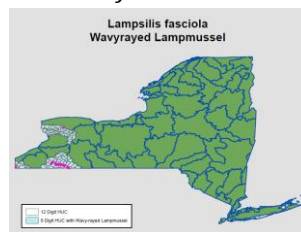


Figure 2: Post 1970 *L. fasciola* distribution in New York State (Mahar & Landry, 2013; Harman and Lord, 2010; The Nature Conservancy, 2009; New York Natural Heritage Program, 2013; White et al., 2011).

**III. New York Rarity, if known:**

| <b>Historic</b>      | <b><u># of Animals</u></b> | <b><u># of Occurrences</u></b> | <b><u>% of State</u></b>        |
|----------------------|----------------------------|--------------------------------|---------------------------------|
| <b>prior to 1970</b> | <u>&lt;20 specimens</u>    | <u>3 waterbodies</u>           | <u>3 of 56 HUC 8 watersheds</u> |
| <b>prior to 1980</b> | <u>_____</u>               | <u>_____</u>                   | <u>_____</u>                    |
| <b>prior to 1990</b> | <u>_____</u>               | <u>_____</u>                   | <u>_____</u>                    |

**Details of historic occurrence:**

Prior to the 2005 Nature Conservancy survey of the Allegheny basin, fewer than 20 specimens had ever been seen in the New York. Historically, *L. fasciola* has been collected in the Great Lakes basin from the Niagara River, Medina (presumably Oak Orchard Creek), and the Genesee River (Strayer and Jirka 1997).

| <b>Current</b> | <b><u># of Animals</u></b> | <b><u># of Occurrences</u></b> | <b><u>% of State</u></b>        |
|----------------|----------------------------|--------------------------------|---------------------------------|
|                | <u>~84 live</u>            | <u>6 waterbodies</u>           | <u>3 of 56 HUC 8 watersheds</u> |

**Details of current occurrence:**

Since 1970, *L. fasciola* has been found in six New York State waterbodies (Figure 2).

Between 2005 and 2007, 79 live *L. fasciola* were found in the Allegheny River between Olean and Salamanca and in Oswayo Creek, a tributary to the Allegheny River. It was also found as shells in Olean Creek. They were never considered abundant at any sites but greatest catches were in the Allegheny River around Olean and in Oswayo Creek. This species was considered viable at 8 of 22 sites where it was found (The Nature Conservancy, 2009). One more live *L. fasciola* was found in Allegheny River at Olean in 2013 (Burlakova, Karatayev, unpublished data). In 2009, five live individuals and one spent shell found in Red House Brook, a tributary to the Allegheny River (New York Natural Heritage Program, 2013). There is also an occurrence recorded for French Creek (NY Natural Heritage Program, 2013; 2 live found in 2013; Burlakova and Karatayev, unpublished data).

In the Erie Basin’s Tonawanda Creek, four spent shells, two of which were recently dead, were found in 1998 (New York Natural Heritage Program, 2013), and one live mussel in 2011 (Burlakova, unpublished data).

**New York's Contribution to Species North American Range:**

| <b>% of NA Range in New York</b>         | <b>Classification of New York Range</b>        |
|--|--|
| <input type="checkbox"/> 100 (endemic)   | <input type="checkbox"/> Core                  |
| <input type="checkbox"/> 76-99           | <input checked="" type="checkbox"/> Peripheral |
| <input type="checkbox"/> 51-75           | <input type="checkbox"/> Disjunct              |
| <input type="checkbox"/> 26-50           | <b>Distance to core population:</b>            |
| <input checked="" type="checkbox"/> 1-25 | <u>375 miles</u>                               |

**IV. Primary Habitat or Community Type:**

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

**Habitat or Community Type Trend in New York:**

Declining       Stable       Increasing     Unknown

**Time frame of decline/increase:** \_\_\_\_\_

**Habitat Specialist?**                       Yes       No

**Indicator Species?**                       Yes       No

**Habitat Discussion:**

Watters et al. (2009) describes *L. fasciola* as a high-water-quality species of fast moving water. It is mainly found in and around riffle areas of clear, hydrologically stable, small- to medium-sized streams and rivers of various sizes, at depths of up to 1 m with clean substrates of gravel and sand, stabilized with cobble and boulders (Watters et al., 2009; Strayer & Jirka, 1997; Metcalfe-Smith et al., 2005; Cummings & Mayer, 1992). Although, according to Spoo (2008) this species buries itself in mud, fine sand, or a sand-gravel mix. Its habitat specificity is considered by NatureServe (2013) to be narrow to moderate.

**V. New York Species Demographics and Life History**

- Breeder in New York**
- Summer Resident**
- 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, *L.fasciola* must parasitize an often specific vertebrate host to complete its life cycle. It is suspected that some mussel populations are not recruiting because their hosts no longer occur with them. Once released by the female, glochidia must acquire a suitable host or die, usually within 24-48 hours. After attaching to a suitable host, glochidia encyst, usually at the fish's gills or fins and receive food and dispersal. Once the glochidia metamorphose into juveniles, they drop from the host. If they land in suitable habitat, they will burrow into the substrate, where they may remain for several years (Watters et al., 2009).

In the adult form, freshwater mussels are basically sessile; movement is limited to a few meters of the lake or river bottom. The only time that significant dispersal can take place is during the parasitic phase. Infected host fishes can transport the larval unionids into new habitats, and can replenish depleted populations with new individuals. Dispersal is particularly important for genetic exchange between populations. Dispersal is likely to be a slow process for mussels which use resident fishes with limited home ranges as their hosts (COSEWIC as cited in NatureServe, 2013).

It has a periodic life history strategy, characterized by moderate to high growth rate, low to intermediate life span, age at maturity, and fecundity, but generally smaller body size than



opportunistic species. Most species 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).

*L. fasciola* is bradytictic, with glochidia overwintering on the female. This species spawns in August, and is gravid the following May to August, although it is suspected that this species may have two broods per year with gravid females found from August to October and again from April to August (Zale & Neves, Ortmann, and Watters & O'Dee as cited in Watters et al., 2009). Glochidia have been found to transform on largemouth bass (*Micropterus salmoides*) and longear sunfish (*Lepomis megalotis*). An additional possible host for this species is smallmouth bass (*Micropterus dolomieu*) (Strayer & Jirka, 1997; Watters et al., 2009, Spoo 2008, Zale & Neves, 1982a; 1982b). Specimens greater than 20 years old are rare (Watters et al., 2009).

## VI. Threats:

### **Agricultural Runoff**

The largest populations of *L. fasciola* are found in the Allegheny basin, between Olean and Salamanca. Roughly half of this length of stream is bordered by agriculture, primarily in the Olean/Allegheny area (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 runoff is also a concern. High inputs of nitrogen from fertilizers can cause increases in ammonia in the water and the substrate, leading to direct toxicity for a wide range of mussel species. Mussels, especially in their early life stages, are more sensitive to un-ionized ammonia than

other organisms, and high sensitivity is seen across a range of species and life histories (Haag, 2012). In addition, ammonia adsorbs to sediment particles, resulting in higher nitrogen concentrations in the substrate than in the overlying water. The nitrogen present in the interstitial spaces in the substrate is thought to result in juvenile mortality and to prevent recruitment by some mussel species (Strayer and Malcom, 2012). Studies have suggested decreasing sediment loads entering aquatic systems as the best way to decrease the impact of numerous stressors for mussels in general (Roley et al. 2012).

### **Runoff from Developed Land**

Between Olean and Salamanca, the Allegheny River is intermittently bordered by interstate highways, state routes, and several local roads. In addition, the habitat of *L.fasciola* receives stormwater runoff from the cities of Olean, Salamanca, and the village of Portville, either directly to the Allegheny River or through tributaries (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).

### **Treated Waste Water**

The habitat of *L.fasciola* receives treated waste water from the cities of Olean, Salamanca, and the village of Portville, either directly to the Allegheny River or through tributaries (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 disruptors from pharmaceuticals are also present in municipal sewage effluents and are increasing common in rivers and lakes (Haag, 2012). In mussels, chronic exposure to estrogenic compounds in effluents caused feminization of male mussels, but these individuals did not produce eggs, suggesting major disruption of reproductive function (Gagne et al. 2011). The long term effects of these compounds on mussels are unknown (Haag 2012). It should be noted that in the Susquehanna basin, Harman and Lord (2010) found no evidence that waste water treatment plants were responsible for reductions in mussel species of greatest conservation need.

### **Flood Control Projects**

Within the habitat of *L.fasciola*, large stretches of the Allegheny River are in leveed, water control projects, requiring periodic maintenance ("New York State Flood Protection," 2013). Additionally, many smaller streams have been channelized and bermed by landowners and highway departments to protect farm fields and other structures. These structures confine larger rivers, preventing the

river from inundating its natural floodplains and wetlands to minimize flood damage. Channelization and dredging associated with flood control projects are catastrophic to mussels and have been implicated in the decline of some populations (Watters et al., 2009). The result of these projects is altered seasonality of flow and temperature regimes, increased stream velocities, unstable substrates, changed patterns of sediment scour and deposition, including streambank erosion, altered transport of particulate organic matter (the food base for mussels), and a general degradation of stream habitat (Benke, 1999; Yeager, 1993; Nedeau, 2008).

### **Other Ecosystem Modifications**

Ecosystem modifications, such as isolated occurrences of canal dredging, instream work associated with bridge replacement, gravel removal, 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).

### **Climate Change**

In a recent assessment of the vulnerability of at-risk species to climate change in New York, Schlesinger et al. (2011) ranked this species as “moderately vulnerable.” This indicates that abundance and/or range extent within New York is likely to decrease by 2050.

### **Other**

Studies show that *L. fasciola* abundance and distribution is highly dependent on the presence of specific host fish (McNichols et al., 2010). Degradation of host fish species from the ecosystem can result in lowered reproduction rates, thus reducing the *L. fasciola* population.

### **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

Yes

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

Mussel habitats receive some generic protection under several New York State regulations (NYCRR) promulgated under the authority of the New York Environmental Conservation Law (ECL), specifically Part 608 of the NYCRR: Use and Protection of Waters, and Part 617 of the NYCRR: State Environmental Quality Review (SEQR). Part 608 provides protection of some mussel habitats by regulating and requiring environmental review of the modification or disturbance of any “protected stream”, its bed or bank, and removal of sand, gravel or other material from its bed or banks (608.2 Disturbance of Protected Streams). This does not provide adequate protection of mussels and their habitats as it only protects streams or particular portions of a streams for which there has been adopted by NYSDEC or any of its predecessors any of the following classifications or standards: AA, AA(t), A, A(t), B, B(t) C(t), or Streams designated (t)(trout) also include those more specifically designated (ts)(trout spawning). 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 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:**

- Priority conservation efforts for this species should focus on, but not be limited to, Oswayo Creek and the Allegheny River near Olean.
- 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).
- 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.
- Establish a protocol whereas DEC staff work closely with flood control management to reduce or impacts to native mussels during maintenance flood control projects.
- 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.
- 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 & 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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