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The Status of Freshwater Mussels in Rhode Island

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Abstract - Between 1980 and present, we inventoried freshwater mussel populations at 129 aquatic sites throughout Rhode Island. We found 8 native mussel species and documented the presence of *Corbicula* sp. (Asiatic clam). The Rhode Island mussel fauna has been degraded by a long history of damming and discharges into rivers. Significant lake populations have also been eliminated by basin reconfigurations, pollution, and urban development. *Elliptio complanata* is currently the most widespread and common Rhode Island species. *Pyganodon cataracta* and *Alasmidonta undulata* are also widespread but less common. *Anodonta implicata* and *Pyganodon cataracta* may be expanding because of increased fish passage and stocking. *Lampsilis radiata*, *Ligumia nasuta*, *Margaritifera margaritifera*, and *Strophitus undulatus* are rare or localized and should be considered high conservation priorities in Rhode Island.

Introduction

North America contains a high proportion of the world's freshwater mussel fauna. Unfortunately, several mussel extinctions have already occurred and many other species are imperiled (Bogan 1993, Nedeau et al. 2000, Williams et al. 1993). Although Rhode Island does not host any mussel species endangered range-wide, populations are nevertheless at risk from a variety of threats to freshwater ecosystems (Richter et al. 1997). Tracking historical changes in composition and abundance of Rhode Island mussel populations has been problematic because a systematic survey of the State's freshwater mussels did not exist. Therefore, we sampled several freshwater habitats to document the distribution and relative abundance of species. These data provide important benchmarks against which to compare future surveys of these beleaguered populations.

A brief summary of the biology of freshwater mussels is germane to subsequent discussions of distribution and status in Rhode Island. At the onset of reproduction, male mussels release sperm into the water column. Females siphon the sperm from the water and fertilize eggs internally within modified areas of the gills called marsupia. Eggs then develop into larval forms known as glochidia. The glochidia resemble little traps or castanets—two toothy jaws joined by a single hinge. When expelled by the female, the glochidia must clamp onto the fins, scales, or gills of a suitable aquatic vertebrate host, a fish or amphibian. Following attachment, the glochidia encyst within the host tissues and derive sustenance from body fluids. The host is usually not harmed by this process. When the glochidia have devel-

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Dick,
here are the 2 reprints I have promised you. Unfortunately they are photocopies but that is the best I can do since I no longer have a surplus of originals. You may want to make a photocopy of Hendrix et al and keep one, since this is the only documentation that 30 acre Pond had at one time 5 sps of unios of which I found parasites in 2 of them +
P. cataracta ×
L. nasuta ×
E. complanata
A. undulata
L. radiata
+ maybe A. implicata
see pg 295 of Hendrix et al

Ray Hartenstine

PS Thanks again for taking a look at the water chemistry data from Warwick Pond + letting me know that excess amonia in the pond killed off the surviving population of E complanata + A. implicata. This event happened sometime in 2002 to 2005. over →

oped into tiny mussels, they drop off the host and settle into the benthos. The interested reader is directed to several fine recent publications that illustrate species, discuss aspects of life history, describe habitats, and compile known hosts for local mussels (Nedeau et al. 2000; Nedeau and Victoria, undated; Strayer and Jirka 1997).

Methods

We solicited major North American mussel collections for historical Rhode Island mussel specimens and examined much of this historical material. We also consulted peer-reviewed literature mentioning Rhode Island mussel populations. We then conducted surveys to assess current population levels and relative abundances of mussels. To find mussels, we primarily waded in shallow water and inspected the substrate with viewing boxes. We used canoes and kayaks to reach inaccessible sections of streams or large lakes and occasionally used diving gear to inventory sites. We did not inventory turbid or deep aquatic sites. We also surveyed shell middens created by *Ondatra zibethicus* (Linnaeus) (muskrat) and *Lontra canadensis* (Schreber) (North American river otter). Shell middens were excellent sources of specimens in areas that were difficult to collect by other techniques. For each site visit, we recorded the date, time, duration of visit, survey method, approximate area surveyed (shoreline distance or stream length), weather and viewing conditions, habitat type, and substrate. We sampled the following frequencies of habitats: natural lake (14), stream or river length (91), impoundment (9), modified river length (3), modified lake (7), canal (3), and artificial pond (2). Modified lakes and modified rivers were sites where the water depth had been stabilized by dams. Impoundments and artificial ponds were sites having no original lentic habitat, i.e., damming a stream created a pond where none had previously existed. We counted individuals of uncommon mussels and qualified other species encountered as "common" or "abundant." We collected empty valves for voucher specimens when possible, but also took live animals on occasion for this purpose. We donated this material to the collections of the Illinois Natural History Survey (INHS) and the Museum of Comparative Zoology, Harvard University (MCZ). Several contributors also supplied valves collected during other investigations. Such specimens indicated species presence, but may not accurately reflect the entire local mussel fauna. Therefore, we considered such information as partial data. If we conducted a reasonable effort during conditions suitable for detection of all potential species, we considered the survey complete. We compiled the data with ArcView 3.1 GIS software (Environmental Systems Research Institute, Redlands, CA) to be spatially compatible with other statewide Rhode Island Geographic Information System (RIGIS) data layers (August et al. 1995) and used RIGIS data to create the accompanying maps.

← I forward this information to the Buckeye Brook ~~Coalition~~ Coalition to help them fight the antifreeze pollution generated by the T.F. Green Airport and drains into Warwick Pd + Buckeye Brook.

Ray

Results

We obtained data for 199 discrete Rhode Island localities of varying size and visited several of these repeatedly. We surveyed 129 sites completely and had partial data for 70 other sites. We recorded 8 mussel species: *Alasmidonta undulata* (Say), *Anodonta implicata* Say, *Elliptio complanata* (Lightfoot), *Lampsilis radiata* (Gmelin), *Ligumia nasuta* (Say), *Margaritifera margaritifera* (Linnaeus), *Pyganodon cataracta* (Say), and *Strophitus undulatus* (Say). We did not find three species that occur in nearby areas of Connecticut and Massachusetts: *Alasmidonta heterodon* (Lea), *Alasmidonta varicosa* (Lamarck), and *Leptodea ochracea* (Say). Carpenter (1890) claimed that *A. varicosa* was "found very sparingly in the Blackstone River, just above the Tin Bridge in Central Falls." Despite this statement, however, we are unaware of any Rhode Island specimens of *A. varicosa*. *Alasmidonta heterodon* and *L. ochracea* are similarly not documented from Rhode Island. The following summary of our recent sampling pertains to complete surveys only. We found no mussels at 41 localities. The remaining 88 localities contained between 1 and 5 species. Of these, 34 sites contained *E. complanata* only, *P. cataracta* only, or both species. The remaining species were either locally distributed or uncommon. In the following narrative, the terms Basin and Subbasin are consistent with RIGIS watershed labeling protocols. See Figure 1 for locations of selected Rhode Island watersheds and aquatic features.

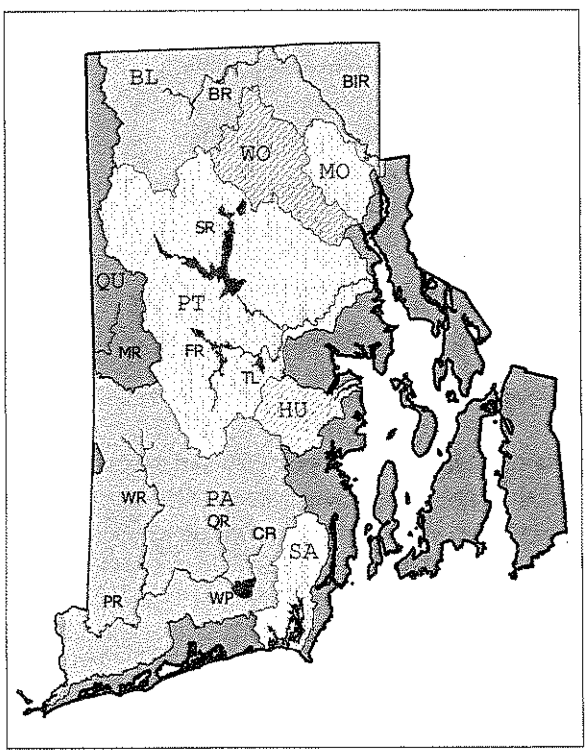

Figure 1. Rhode Island watersheds and selected aquatic features. Watershed names (large text) as follows: BL = Blackstone, C = Coastal, HU = Hunt, MO = Moshassuck, PA = Pawcatuck, PT = Pawtuxet, QU = Quinebaug, SA = Saugatucket, and WO = Woonasquatucket. Aquatic features (small text) as follows: BLR = Blackstone R., BR = Branch R., CR = Chipuxet R., FRR = Flat R. Reservoir, MR = Moosup R., PR = Pawcatuck R., QR = Queen's R., SR = Scituate Reservoir, TL = Tiogue Lake, WP = Worden's Pond, and WR = Wood R.

Species richness at sites ranged from 0 to 5. Localities with high species richness were confined to the Pawcatuck River and Pawtuxet River Basins. Only the Pawcatuck River Basin supported all local mussel species. Within the Pawcatuck River Basin, we found all sites with high (4–5) species richness within the Queen's River, Chipuxet River, and Pawcatuck River Sub-basins. The primary epicenters of Rhode Island mussel diversity are presently located in the headwaters of the Pawcatuck River Basin and in the South Branch River Sub-basin of the Pawtuxet River Basin. Insular populations of mussels are few. *Pyganodon cataracta* occurs in at least 3 reservoirs on Aquidneck Island and *E. complanata* may be extant at a former Newport (Almy Pond) locality. Conanicut Island, Prudence Island, and Block Island have no mussel fauna.

Species Accounts

The frequencies described in the following accounts are based on 129 complete site surveys unless otherwise stated. The species accounts are arranged in order of decreasing frequency of detection.

Elliptio complanata (Lightfoot)

Elliptio complanata (Fig. 2) was the most widespread species, found in 58% of occupied sites, and was the only species found in 23 sites (18%). We found *E. complanata* in a variety of river and pond habitats, and it

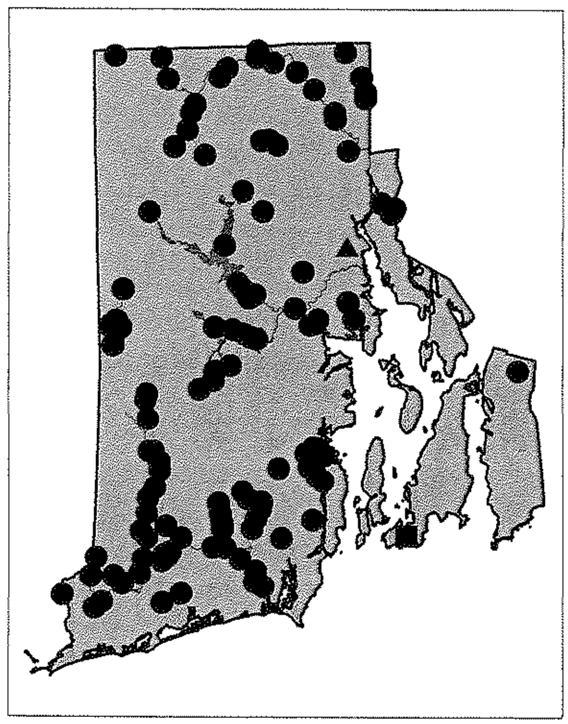

Figure 2. Distribution of *Elliptio complanata*. Circles indicate recent locations, triangles indicate historical sites now extirpated, squares indicate historical sites not resurveyed.

often occurred with *P. cataracta* in modified rivers and lakes with poor water quality. *Elliptio complanata* was also the only species that could be considered common—it vastly outnumbered all other species in mixed assemblages. For this reason, casual reports of mussels (incomplete surveys) usually involved *E. complanata*. We did not estimate density, but sizeable *E. complanata* populations were located in Worden's Pond (South Kingstown), the South Branch of the Pawtuxet River (Coventry), and the Branch River in the Blackstone Basin (North Smithfield). Although widespread, this species seemed more common in natural lakes and rivers near the coast and less common in interior waters, many of which were impounded high-gradient streams. Most populations featured a mix of size classes, indicative of recruitment.

***Pyganodon cataracta* (Say)**

Pyganodon cataracta (Fig. 3) was the next most widespread species. We found *P. cataracta* at 21% of occupied sites, but it was the sole species present at only 3 sites. Incomplete surveys reported this species often, but less than *E. complanata*. We found *P. cataracta* predominantly in ponds and slow rivers, often in modified habitats (e.g., reservoirs). We suspect, as noted by Smith (1982), that *P. cataracta* has been introduced by translocations of fish, because we found this species in farm-ponds that were not connected to other water bodies. On Aquidneck Island, *P. cataracta* occurred abundantly in Sisson Pond (Middletown), St. Mary's Pond

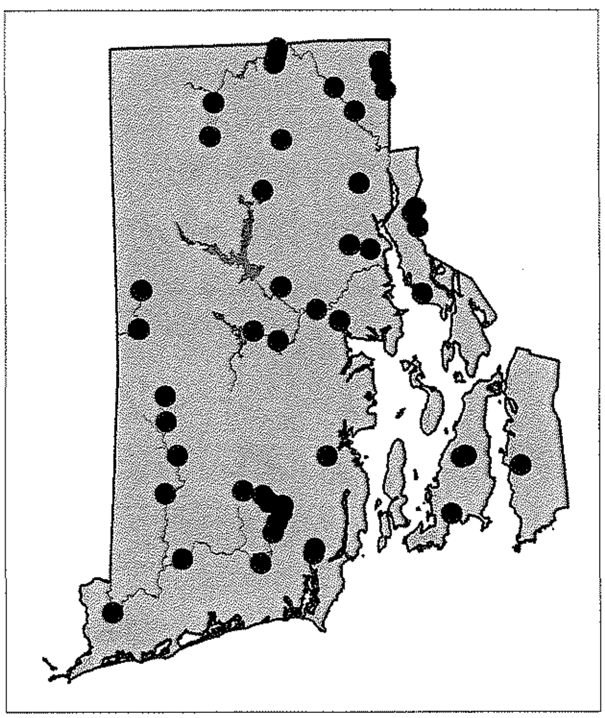

Figure 3. Distribution of *Pyganodon cataracta*. Circles indicate recent locations, triangles indicate historical sites now extirpated, squares indicate historical sites not resurveyed.

(Middletown), and Easton's Pond (Newport), all reservoirs for the City of Newport. Water is pumped into these holding ponds through a pipeline that originates in the town of Little Compton, across the East Passage of Narragansett Bay. We believe that *P. cataracta* gained access to the Aquidneck Island reservoirs through this conduit or was introduced in some other fashion. Known host fish for *Pyganodon cataracta* include *Lepomis gibbosus* (Linnaeus) (pumpkinseed) and *Lepomis macrochirus* Rafinesque (bluegill), among the most widely distributed and translocated fish species in Rhode Island (A. Libby, RI Division of Fish and Wildlife, pers. comm.).

Alasmidonta undulata (Say)

Alasmidonta undulata (Fig. 4) was fairly widespread, occurring at 20 sites (16%), but was usually uncommon at any given site. We generally encountered this species in rivers, especially in sand or gravel substrate of riffles and runs below dams. Exceptions to this pattern were thriving populations in two small artificial ponds that had a stream connection to nearby rivers. *Alasmidonta undulata* was usually found as a small fraction of the entire mussel population. However, in a stretch of the Pawtuxet River below Natick Dam (West Warwick), *A. undulata* was the only species encountered and was also abundant there, occurring at a density of nearly 50 individuals per m^2. Based on observation of small individuals, there seemed to be recent recruitment at most *A. undulata* sites.

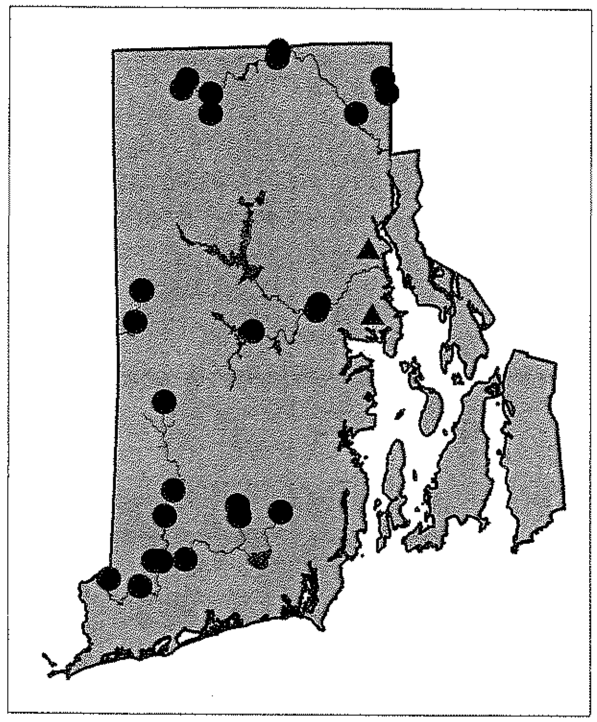

Figure 4. Distribution of *Alasmidonta undulata*. Circles indicate recent locations, triangles indicate historical sites now extirpated, squares indicate historical sites not resurveyed.

Anodonta implicata Say

Anodonta implicata (Fig. 5) occurred at 12 sites in coastal rivers and ponds. This species occurred in the Pawcatuck River as far upstream as the village of Carolina (Richmond) and northward to Mechanic Street Dam (Hopkinton/Richmond) in the Wood River. Because fish passage was impeded at the village of Alton (Hopkinton/Richmond), downstream from this site, *A. implicata* may have reached Mechanic Street through transplantation of its host fish, *Alosa* spp. (river herring). On the western side of Narragansett Bay we found *A. implicata* in the Saugatucket River (South Kingstown), Potowomut River at Forge Road (Warwick), and Gorton Pond (Warwick). On the east side of Narragansett Bay, we found *A. implicata* in Brickyard Pond (Barrington) and Nonquit Pond (Tiverton), both of which supported herring runs. We did not find *A. implicata* at all known herring runs. Active runs lacking this species included Carr Pond/Gilbert Stuart Mill (North Kingstown) and the Annaquatucket River west to Belleville Pond (North Kingstown). *Anodonta implicata* is the only species besides *P. cataracta* for which recent range expansion can be hypothesized. Historical collectors apparently did not often encounter this species in Rhode Island. For example, Johnson (1946) denoted the two primary historical localities at Cunliff's Pond (Providence/Cranston) and Warwick Pond (Warwick). We found *A. implicata* extant at Warwick Pond, but also found it at several other Rhode Island sites, suggesting recent colonization. Smith (1985) thought

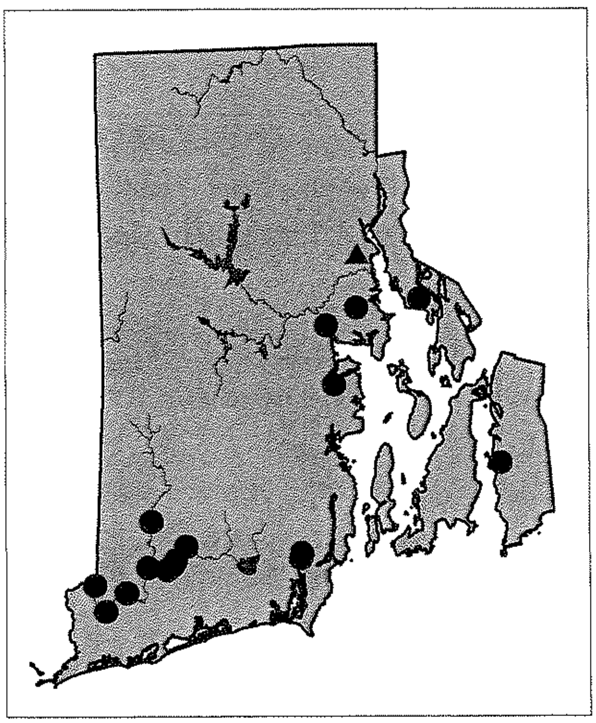

Figure 5. Distribution of *Anodonta implicata*. Circles indicate recent locations, triangles indicate historical sites now extirpated, squares indicate historical sites not resurveyed.

this species had recently expanded its range because of anadromous fish restoration projects. Restoration typically involves the construction of fish passages at dams and translocation of river herring. In Rhode Island, anadromous fish restoration began about 1979 with construction of a fish ladder at Potter Hill (Westerly)(P. Edwards, RIDFW, pers. comm.) and several other ladders have since been constructed. With more anadromous fish projects planned for Rhode Island in the future, we expect *A. implicata* to become more widespread.

Lampsilis radiata **(Gmelin)**

Lampsilis radiata (Fig. 6) occurred primarily in natural lakes and connecting rivers. We found *L. radiata* to be uncommon and localized, recording this species at only 10 localities within the Pawtuxet River and Pawcatuck River Basins. In the Pawtuxet River Basin, *L. radiata* occurred in the Moswansicut Reservoir Sub-basin and South Branch River Sub-basin. Moswansicut Reservoir (Scituate/Johnston) is a shallow natural lake, one of few such habitats in Rhode Island. We also found *L. radiata* in the South Branch River Sub-basin at Tiogue Lake (Coventry) and in the Flat River Reservoir and its exit stream, the South Branch River (both in Coventry). Within the Pawcatuck River Basin, we found *L. radiata* only within the natural lakes and connecting rivers that extend from Hundred Acre Pond (South Kingstown) through Thirty Acre Pond (South Kingstown) and, via the Chipuxet River (South Kingstown), to Larkin's Pond (South Kingstown) and Worden's Pond.

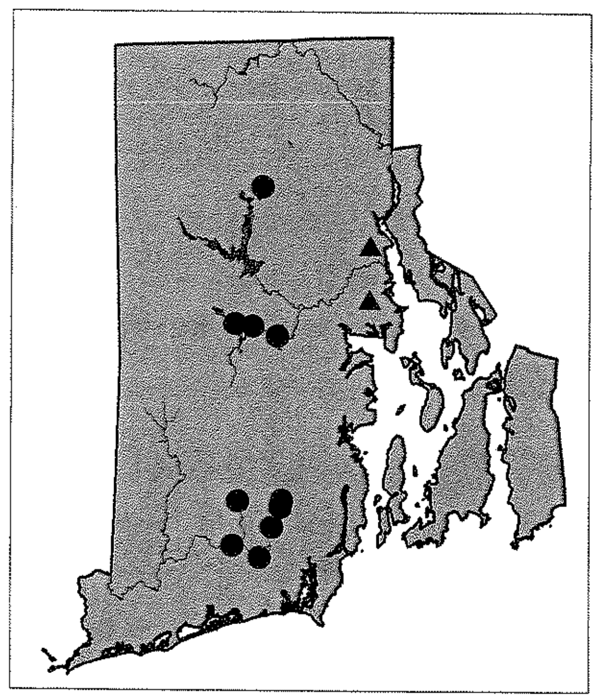

Figure 6. Distribution of *Lampsilis radiata*. Circles indicate recent locations, triangles indicate historical sites now extirpated, squares indicate historical sites not resurveyed.

Ligumia nasuta (Say)

Ligumia nasuta (Fig. 7) sometimes occurred with *Lampsilis radiata* in natural lakes and associated rivers. For example, we found both species in Worden's Pond, Larkin Pond, Hundred Acre Pond, and Thirty Acre Pond. However, we found *L. nasuta* only within the Pawcatuck River Basin. We could not document it within the Pawtuxet River Basin, even at *L. radiata* sites, and could also not relocate *L. nasuta* at the historical Cunliff's Pond and Warwick Pond localities. *L. nasuta* was moderately common only in Worden's Pond and perhaps at Chapman Pond (Westerly), where the presence of small individuals indicated recruitment. At other sites we observed only a few individuals. *L. nasuta* is therefore one of the most localized and uncommon of Rhode Island's mussels.

Margaritifera margaritifera (Linnaeus)

Margaritifera margaritifera (Fig. 8) occurred primarily in headwater streams of the Pawcatuck River Basin, especially in the Wood River Subbasin. Within the Wood River and its tributaries, we did not find this species north of Austin Farm Road, in the Arcadia Management Area (Exeter/West Greenwich). South of Austin Farm Road, *M. margaritifera* was moderately common in the Flat, Falls, and Wood Rivers downstream to Barberville Dam (Hopkinton/Richmond). We also resurveyed the historical locality for this species mentioned by Davis (1905) and other sources as "outlet of Boone Lake" (Roaring Brook [Exeter]) and found *M. margaritifera* extant there, albeit in very low population levels (9 individuals seen in 0.25 miles of river).

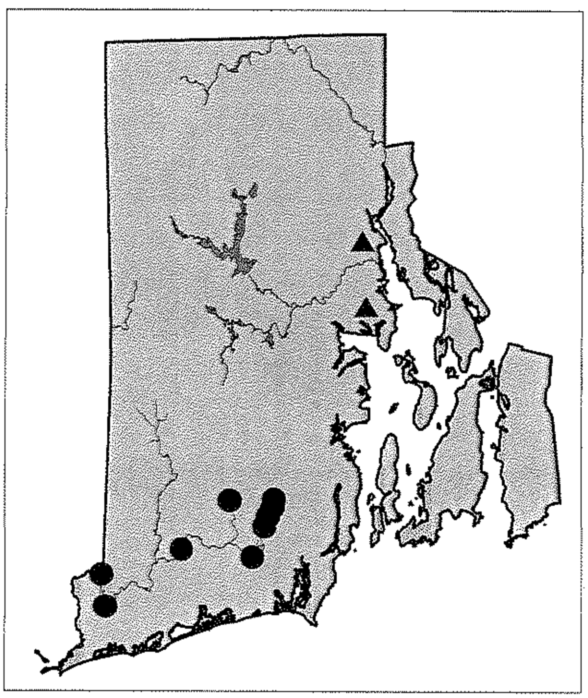

Figure 7. Distribution of *Ligumia nasuta*. Circles indicate recent locations, triangles indicate historical sites now extirpated, squares indicate historical sites not resurveyed.

M, margaritifera was usually the only species found where it occurred, but we also detected it sparingly within mixed assemblages in the better riffle areas of the lower Pawcatuck River, as at Potter Hill and White Rock (Westerly). There is sparse documentation of this species away from the aforementioned areas. There was an historical record from the town of Foster (Providence County), exact locality unknown. In the early 1990s, we found *M. margaritifera* at single localities within the Blackstone River Basin at the Tarkiln River (Burrillville) and in the Pawtuxet River Basin at the North Branch River near the village of Hope (Scituate).

Margaritifera margaritifera populations have suffered dramatic declines even within the scope of this survey. Streams within the Arcadia Management Area formerly hosted large populations of *M. margaritifera.* In the 1980s, this species was so common in the Flat and Falls Rivers (Exeter) that one could not wade without stepping on one. At that time, however, these sites contained mostly large mussels and there was little evidence of reproduction. Recently, *M. margaritifera* has declined to the point of near extirpation in one of those rivers. A population in Beaver River (Richmond) has concurrently declined. In 1990, we observed about 15 *M. margaritifera* in a 100-foot section of Beaver River downstream from Rt. 138. In 2001, we resurveyed this area and found only 3, well south of the original survey area. There are no known extant localities known for *M. margaritifera* in the Pawtuxet River Basin. In 1990, we observed several *M. margaritifera* in the North Branch River at the village of Hope. Water diversions from the main

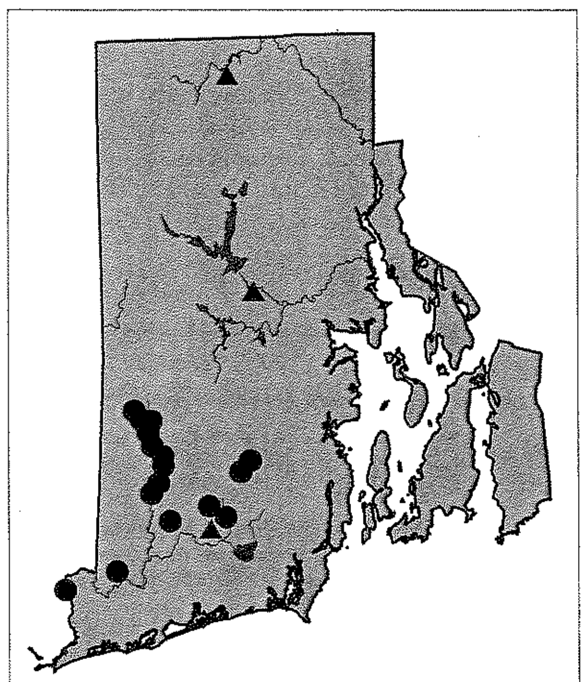

Figure 8. Distribution of *Margaritifera margaritifera.* Circles indicate recent locations, triangles indicate historical sites now extirpated, squares indicate historical sites not resurveyed.

stream of the river below the dam, sometime prior to 2000, apparently caused the extirpation of *M. margaritifera*, because subsequent surveys have not detected it. *Margaritifera margaritifera* is also no longer known from the Rhode Island portion of the Blackstone River Basin. We observed this species in the Tarkiln River (Burrillville) in 1990, but by 1994 this population was gone, the river degraded by pollution.

We do not understand why *M. margaritifera* has declined so precipitously in some areas of former abundance. Although water diversions and contamination have obviously destroyed some populations, other sites in the Arcadia Management Area have not ostensibly changed. However, few individuals remain at some of these sites. We plan to resurvey these stretches of river in the near future and will try to correlate *M. margaritifera* population characteristics with habitat variables, landscape composition, and fish populations.

***Strophitus undulatus* (Say)**

Strophitus undulatus (Fig. 9) was not only localized in distribution (6 sites), but was also uncommon. We found this species primarily in higher quality riffle areas in larger rivers. One notable exception was a large midden of fresh *S. undulatus* shells, apparently derived from a population in an artificial pond at a farm west of Alton (Hopkinton). This pond had a stream connection to the Wood River. Except for this inexplicable pond situation, *S. undulatus* was usually found sparingly among robust populations of more common species; i.e., a quality river assemblage might also

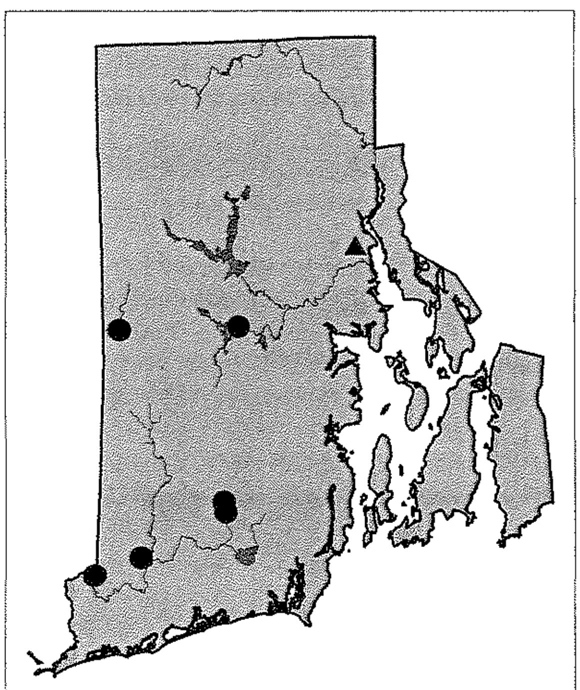

Figure 9. Distribution of *Strophitus undulatus*. Circles indicate recent locations, triangles indicate historical sites now extirpated, squares indicate historical sites not resurveyed.

contain a few *S. undulatus*. The best populations occurred in the Queen's River (Pawcatuck River Basin), the Moosup River (Quinebaug River Basin), and the South Branch River (Pawtuxet River Basin). Although we found evidence of recruitment at the Queen's River and Moosup River sites, *S. undulatus* was so uncommon and localized that its future in Rhode Island seems tenuous. *Strophitus undulatus* is clearly one of the highest priorities for mussel conservation in Rhode Island.

Discussion

Although comparisons to the historical era are difficult, we infer that Rhode Island's present mussel fauna has been vastly reduced from its ancestral condition. Some sites known to historical collectors have been extensively degraded. Cunliff's Pond was formerly a large natural lake on the Providence/Cranston border. This site was put on the malacological map in 1871, when Horace Carpenter (1890) discovered a population of *Ligumia nasuta*. This site also supported *Anodonta implicata*, *Elliptio complanata*, *Strophitus undulatus*, *Lampsilis radiata*, and *Alasmidonta undulata* (Davis 1905). This lake was completely reconfigured during "improvements" to Roger Williams Park. In a published history of the Park, Marshall (1987) stated, "by this year (1897), the dredging and removal of muck at various sites have resulted in the construction of the following lakes: Crystal, Willow, Polo, Pleasure, Cunliffe, Deep Spring." According to Davis (1905), "Cunliff Pond was all drained off a few years ago, and bushels of unios taken out." However, Davis found that most species subsequently recolonized, apparently surviving in the refugium of Cunliff Brook, a connector stream to Mashapaug Pond. Today these lakes are so polluted and turbid that sampling is virtually impossible. However, our survey attempts detected only *Pyganodon cataracta* within Roger Williams Park. Warwick Pond was another noteworthy historical Rhode Island collecting locality. Known from this natural lake were *Alasmidonta undulata*, *Lampsilis radiata*, *Ligumia nasuta*, and *Anodonta implicata*. On two occasions we examined this pond with extensive snorkel surveys and found sizeable numbers of only *Elliptio complanata* and *Anodonta implicata*, but the populations consisted only of large individuals. Even though the pond had not been physically altered, except by home construction around the margins, the mussel fauna had obviously degraded, perhaps because of pollution.

Statewide, we found few localities containing robust "paving-the-bottom" populations, and in many locations, mussels were either uncommon or absent. River populations have undoubtedly been severely depleted by dams and industrial discharges. Because the 1793 Slater Mill (Pawtucket) was one of the harbingers of the Industrial Revolution (Davis and Robinson 1986), Rhode Island has a long history of river degradation. In the Blackstone River Basin, although water quality has improved and fish populations have partially recovered, the effects of past aquatic traumas are apparent. Only the three most widespread species (*E. complanata*, *P. cataracta*, *A. undulata*) are known to occur in the Blackstone River Basin. Many stretches of Blackstone River tributaries had no mussel fauna at all, despite apparently suitable water and substrate conditions. We conclude that the mussel fauna in the Blackstone River Basin was decimated by past industrial development, and that recovery of mussels has been hindered by the inability of fish to re-colonize those river stretches still isolated by dams.

The Pawtuxet River Basin is in only slightly better condition. This system presently supports 6 mussel species, but lacks *L. nasuta* and *M. margaritifera*. Although reservoir development has inundated much former river habitat, some rivers immediately downstream of the reservoirs are functioning as refugia and support large and diverse mussel populations. However, these stretches of quality river habitat are extremely limited and obviously vulnerable. As with the Blackstone Basin, there are many sections of river in the Pawtuxet River Basin that seem suitable for mussels, but are eerily devoid of them. For example, we found no mussels at all downstream from Rt. 2 (West Warwick and Warwick), a condition we attribute to industrial and wastewater discharges.

Of the three largest river systems in Rhode Island, only the Pawcatuck River Basin contains populations of all local mussel species. The most significant concentrations of mussels in this system are presently found in the Queen's River and the natural lakes in the upper Pawcatuck River Subbasin. Unfortunately, these lakes are threatened by agricultural run-off and other sources of contamination, as well as from summer water withdrawals that sometimes render connecting streams nearly dry. Several ponds in the upper Pawcatuck River Basin have become obviously more eutrophic since 1980. Mussels depend on stable, relatively clean aquatic habitats. Therefore, even the mussels in the Pawcatuck River Basin are under siege.

Another threat to freshwater ecosystems in Rhode Island may be the introduction of *Corbicula* sp. (Asiatic clam). In 2000, Charles Brown discovered this species at Tiogue Lake (Coventry), in the South Branch River Sub-basin of the Pawtuxet River Basin. We had not detected *Corbicula* in a 1995 survey of Tiogue Lake. Presently this species is known to occur only in Tiogue Lake and has not yet spread to adjacent waterways, but it seems only a matter of time before *Corbicula* becomes widespread and abundant in Rhode Island.

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