Native Freshwater Mussels

Indicator #68

Overall Assessment

Status: **Not Assessed**
Trend: **Not Assessed**
Rationale:

Lake-by-Lake Assessment

Lake Superior

Status: Not Assessed
Trend: Undetermined
Rationale: Only limited data is available for Lake Superior unionid fauna. Some limited surveys have been done in western nearshore waters as well as some inland rivers, but no widespread unionid population assessments are available for open lake waters (see Graf 1997; Graf and Underhill 1997, Nichols et al. 2000). Lake Superior as not been well colonized by dreissenids, so population declines related to this invasive would be limited to a few bays.

Lake Michigan

Status: Not Assessed
Trend: Undetermined
Rationale: Only limited data is available for Lake Michigan unionids. Many inland rivers have been surveyed, but data on open lake populations is rare. Recent sampling has documented declines in other types of benthic fauna due to dreissenid expansion (see Nalepa et.al. 1997). Given the changes in other benthos fauna, and other signs of increasing dreissenid numbers, we hypothesize that unionid densities in the open lake waters have severely declined over the last decade as they have in Lake Erie.

Lake Huron

Status: Not Assessed
Trend: Undetermined
Rationale: Some unionid population trend data is available for Saginaw Bay, and shows rapid decline of unionids right after the zebra mussel invasion. No concerted sampling of unionids out in the main lake has been done. Recent benthos sampling has documented changes in non-unionid benthic fauna due to dreissenid expansion (see Nalepa et.al. 1998). We hypothesize that unionid populations are declining as they have in Lake Erie due to the declines in other benthic species and the ver-increasing dreissenid numbers.

Lake Erie

Status: Poor
Trend: Deteriorating
Rationale: Open water surveys show rapid decline of unionids in many parts of the lake due to interactions with dreissenids (see Schloesser et al. 1996; 1997). Unionid populations do survive in some inland rivers.

Lake Ontario

Status: Undetermined

Trend: Undetermined.

Rationale: There are very few studies looking at unionid population status in open water, though there are surveys of inland rivers in existence. There are general benthos surveys of open waters that show similar changes in other benthic fauna as dreissenid numbers increase. We hypothesize that the unionid population follows the same pattern of decline, with isolated remnant populations as seen in some of the other lakes.

Purpose

- To assess the location and status of freshwater native mussel (unionid) populations and their habitats throughout the Great Lakes system, with emphasis on endangered and threatened species
- To use this information to direct research aimed at identifying the factors responsible for mussel survival in refuge areas, which in turn will be used to predict the locations of other natural sanctuaries and guide their management for the protection and restoration of Great Lakes mussels

Ecosystem Objective

The objective is the restoration of the richness, distribution, and abundance of native mussels throughout the Great Lakes, which would thereby reflect the general health of the basin ecosystems. The long-term goal is for native mussel populations to be stable and self sustaining wherever possible throughout their historical range in the Great Lakes, including the connecting channels and tributaries.

State of the Ecosystem

Background

The richness, distribution, and abundance of mussels reflect the general health of the aquatic ecosystems. Freshwater native mussels (*Bivalvia: Unionacea*) are of unique ecological value as natural biological filters, food for fish and wildlife, and indicators of good water quality. In the United States, some species are commercially harvested for their shells and pearls. These slow-growing, long-lived organisms can influence ecosystem function such as phytoplankton ecology, nutrient cycling , substrate stability, and water quality.. As our largest freshwater invertebrate, freshwater mussels may also constitute a significant proportion of the freshwater invertebrate biomass where they occur. Because they are sensitive to toxic chemicals, mussels may serve as an early warning system to alert us of water quality problems. They are also good indicators of environmental change due to their longevity and sedentary nature. Since mussels are parasitic on fish during their larval stage, they depend on healthy fish communities for their survival—loss of mussels may indicate loss of fish hosts.

Status of freshwater mussels

The abundance and number of species of freshwater mussels have severely declined across North America, including the Great Lakes. Nearly 72% of the 300 species in North America are vulnerable to extinction or already extinct. The decline of unionids has been attributed to a number of human-mediated factors such as commercial exploitation of the shells, water quality degradation (pollution, siltation), habitat destruction (dams, dredging, and channelization) riparian and wetland alterations, changes in the distribution and/or abundance of host fishes, and recently competition with non-native species. In the Great Lakes the exotic mussels, zebra mussels (*Dreissena polymorpha*) and, to a lesser extent, quagga mussels (*D. bugensis*) have caused a severe decline in the remaining unionid populations in the open waters of lakes Erie, Huron, Michigan, and Ontario, along with any infested inland waters. Zebra and quagga mussels (dreissenids) attach to the native mussel's shell, where they interfere with

activities such as feeding, respiration and locomotion - effectively robbing it of the energy reserves needed for survival and reproduction. Native mussels are particularly sensitive to biofouling by zebra mussels and to food competition with both zebra mussel and quagga mussels.

In the open waters of the lower Great Lakes, such as Lake St. Clair and Lake Erie, over 99% of the native mussels of all species were lost as a result of the impacts of dreissenids. Although Lake Erie, Lake St. Clair, and their connecting channels historically supported a rich mussel fauna of about 35 species, unionid mussels were slowly declining in some areas even before the zebra mussel invasion. For example, densities in the western basin of Lake Erie decreased from 10 unionids/m^2 in 1961 to 4/m^2 in 1982, probably due to poor water quality. In contrast, the impact of the zebra mussel was swift and severe. Unionids were virtually extirpated from the offshore waters of western Lake Erie between 1988 and 1990 and from Lake St. Clair between 1988 and 1994, with similar declines in the connecting channels and many nearshore habitats. The average number of unionid species found in these areas before the zebra mussel invasion was 18 (Figure 1). After the invasion, 60% of surveyed sites had 3 or fewer species remaining, 40% of sites had none left, and abundance had declined by 90 to 95%.

It was feared that unionid mussels would be completely extirpated from Great Lakes waters . However, remnant native mussel communities have been found in several nearshore areas (Figure 1). These remnant unionid populations, found in isolated habitats such as river mouths and lake-connected wetlands, are at severe risk.
All of the refuge sites discovered to date have two characteristics in common: they are very shallow (less than 1 to 2 m deep), and they have a high degree of connectivity to the lake, which ensures access to host fishes. These features appear to combine with other factors to discourage the settlement and survival of zebra mussels. Soft, silty substrates and high summer water temperatures in Metzger Marsh, Thompson Bay and Crane Creek encourage unionids to burrow, which dislodges and suffocates attached zebra mussels. Increased predation by nearshore fish have reduced attached dreissenid at some sites..Unionids living in firm, sandy substrates at the nearshore western basin site were nearly infestation-free. The few zebra mussels found were less than 2 years old, suggesting that they may be voluntarily releasing from unionids due to harsh conditions created by wave action, fluctuating water levels and ice scour. The St. Clair Delta site has both wave-washed sand flats and wetland areas with soft, muddy sediments. It is thought that the numbers of zebra mussel veligers (planktonic larval stage) reaching the area may vary from year to year, depending on wind and current direction and water levels.

Populations in these type of refugia are still at risk of extirpation due to their isolation and fragmentation. Reproduction is occurring at some of these sites, but not all. While multiple species are found in these sites, viable population numbers of some rarer species may not be present, leading to concerns over their future survivial. A number of species that are listed as endangered or threatened in the United States or Canada are found in some of these isolated populations in the Great Lakes and in associated tributaries. In the United States, these include the clubshell (*Pleurobema clava*), fat pocketbook (*Potamilus capax*), northern riffleshell (*Epioblasma torulosa rangiana*), and white catspaw (*Epioblasma obliquata perobliqua*). In Canada, the northern riffleshell, rayed bean (*Villosa fabalis*), wavyrayed lampmussel (*Lampsilis fasciola*), salamander mussel (*Simpsonaias ambigua*), snuffbox (*Epioblasma triquetra*), round hickorynut (*Obovaria subrotunda*), kidneyshell (*Ptychobranchus fasciolaris*) and round pigtoe (*Pleurobema sintoxia*) are listed as endangered.

One question has been will populations in open waters recover. Recent work in parts of the St. Lawrence river has shown that unionid populations may persist though at greatly reduced numbers. The St. Lawrence unionid fauna declined precipitously after the initial invasion of dreissenids. After a period of time native mussel numbers stabilized and reproduction is occurring, although body condition of the adults is still poor. Tthe mechanism supporting this survival has not been determined, though no obvious “refugia” conditions seem to be present. One

critical point of difference is that this part of the St. Lawrence River is one of the few areas where food competition with dreissenids and not biofouling was the main cause of death in the unionids.

In inland waters, large scale refugia can be provided by free-flowing rivers and streams due to the limitations of the dreissenid veliger cycle. Flowing water has limited persistent dreissenid colonization potential since the veligers require an average of 20-30 days to develop into the benthic stage and may end up flushing downstream out into the open lake. However, regulated rivers, i.e., those with reservoirs, may not provide refugia. Reservoirs with retention times greater than 20 to 30 days will allow veligers to develop and settle, after which the impounded populations will seed downstream reaches on an annual basis.

Pressures

Zebra and quagga mussel expansion is presently the main threat facing unionids in the Great Lakes drainage basin. Zebra and quagga mussels are now found in all of the Great Lakes and in many associated water bodies, including at least 260 inland lakes and river systems such as the Rideau River in Ontario and in two reservoirs in the Thames River drainage in Ontario.

Other non-native species may also impact unionid survival through the reduction or redistribution of native fishes. Nonnative fish species such as the Eurasian ruffe (*Gymnocephalus cernuus*) and round goby (*Neogobius melanostomus*) can completely displace native fish, thus causing the functional extirpation of local unionid populations.

While zebra and quagga mussels remain the most immediate threat to unionid survival in most fo the Great Lakes, water quality problems associated with organic and inorganic pollutants, continuing changes in land use (increasing urban sprawl, growth of factory farms, etc.), climate change and the associated lowering of water levels, loss of fish hosts, dams, and many other factors will continue to have an impact on unionid populations in the future.

Management Implications

The long-term goal is for unionid mussel populations to be stable and self-sustaining wherever possible throughout their historical range in the Great Lakes, including the connecting channels and tributaries. The most urgent activity is to prevent the further introduction of non-native species into the Great Lakes. A second critical activity is to prevent the further expansion of nonnative species into the river systems and inland lakes of the region where they may seriously harm the remaining healthy populations of unionids that could be used to re-inoculate the Great Lakes themselves in the future.

To ensure the survival of remaining unionids in the Great Lakes basin, and to foster the restoration of their populations to the extent possible, the following actions are recommended:

- All existing information on the status of freshwater mussels throughout the Great Lakes drainage basin should be compiled and reviewed. A complete analysis of trends over space and time is needed to properly assess the current health of the fauna.
- To assist with the above exercise, and to guide future surveys, all data must be combined into a computerized, GIS-linked database (similar to the 8000-record Ontario database managed by the National Water Research Institute), accessible to all relevant jurisdictions.
- Additional surveys are needed to fill data gaps, using standardized sampling designs and methods for optimum comparability of data. The Freshwater Mollusk Conservation Society has prepared a peer-reviewed, state-of-the-art protocol that should be consulted for guidance (Strayer and Smith 2003).

Populations of endangered and threatened species should be specifically targeted.

- The locations of all existing refugia, both within and outside of the influence of zebra and quagga mussels, should be documented, and they must be protected by all possible means from future disturbance.
- Research is needed to determine the mechanisms responsible for survival of unionids in the various refuge sites, and this knowledge should be used to predict the locations of other refugia and to guide their management.
- The environmental requirements of unionids need to be taken into account in wetland restoration projects.
- All avenues for educating the public about the plight of unionids in the Great Lakes should be pursued, as well as legislation for their protection. This includes ensuring that all species that should be listed are listed as quickly as possible.
- The principles of the National Strategy for the Conservation of Native Freshwater Mussels (The National Native Mussel Conservation Committee 1998) should be applied to the conservation and protection of the Great Lakes unionid fauna.

Assessing Data Quality

Insert "x" under the statement that best corresponds with each data characteristic

Data Characteristics	Strongly Agree	Agree	Neutral or Unknown	Disagree	Strongly Disagree	Not Applicable
1. Data are documented, validated, or quality-assured by a recognized agency or organization						
2. Data are traceable to original sources						
3. The source of the data is a known, reliable and respected generator of data						
4. Geographic coverage and scale of data are appropriate to the Great Lakes basin						
5. Data obtained from sources within the U.S. are comparable to those from Canada						
6. Uncertainty and variability in the data are documented and within acceptable limits for this indicator report						
Clarifying Notes:						

Acknowledgments

Authors:

S. Jerrine Nichols (2008), U.S. Geological Survey, Biological Resources Division, Ann Arbor, MI, s_jerrine_nichols@usgs.gov.

Janice L. Smith (2004), Biologist, Aquatic Ecosystem Impacts Research Branch, National Water Research Institute, Burlington, ON, Janice.Smith@ec.gc.ca; and

Sources

Bowers, R., and De Szalay, F. 2003. Effects of hydrology on unionids *(*Unionidae*)* and zebra mussels (Dreissenidae*)* in a Lake Erie coastal wetland. American Midland Naturalist 151:286-300.

Bowers R., Sudomir J., Kershner M. and F.de Szalay. 2005. The effects of predation and unionid burrowing on bivalve communities in a Laurentian Great Lake coastal wetland. Hydrobiologia 545(1):93-102.

Clarke, A.. 1992. "Ontario's Sydenham River, an important refugium for native freshwater mussels against competition from the zebra mussel, *Dreissena polymorpha*." Malacology Data Net 3(1-4):43-55.

Graf, D., and C. Underhill. 1997. The western Lake Superior freshwater mussel (Bivalvia: Unionidae) community and its origin. Occasional Papers on Mollusks 5(74): 409-417.

Graf D. 1997. Northern Redistribution of Freshwater Pearly Mussels (Bivalvia: Unionoidea) During Wisconsin deglaciation in the Southern Glacial Lake Agassiz Region: A Review. American Midland Naturalist, Vol. 138(1):37-47

Haynes, James M., Tisch, Nancy A., Mayer, Christine M., Rhyne, Randall S. 2005. Benthic macroinvertebrate communities in southwestern Lake Ontario following invasion of *Dreissena* and *Echinogammarus*: 1983 to 2000. J. North American Benthological Society: Vol. 24 (1):148–167.

Martel, A., Pathy, D, Madill, J, Renaud, C., Dean, S., and S. Kerr. 2001. Decline and regional extirpation of freshwater mussels *(*Unionidae*)* in a small river system invaded by *Dreissena polymorpha*: the Rideau River, 1993-2000. *Can. J. Zool.* 79(12):2181-2191.

Nalepa, T., Hartson, D., Fanslow, D., Lang, G. and S. Lozano. 1998. Declines in benthic macroinvertebrate populations in southern Lake Michigan. Can. J. Fish. Aquat. Sci., 55: 2402-2413.

Nalepa, T, Fanslow D., Pothoven S., Foley Iii A., And G. Lang. Long-term trends in benthic macroinvertebrate populations in Lake Huron over the past four decades. Journal of Great Lakes Research 33(2):421-436 (2007).

Nichols, S.J., and Amberg, J. 1999. Co-existence of zebra mussels and freshwater unionids; population dynamics of *Leptodea fragilis* in a coastal wetland infested with zebra mussels. *Can. J. Zool.* 77(3):423-432.

Nichols, S.J., and Wilcox, D.A. 1997. Burrowing saves Lake Erie clams. *Nature* 389:921.

Schloesser, D.W., Smithee, R.D., Longdon, G.D., and Kovalak, W.P. 1997. Zebra mussel induced mortality of unionids in firm substrata of western Lake Erie and a habitat for survival. American Malacological Bulletin 14:67-74.

Schloesser D., Nalepa T. And G. Mackie. 1996**.** Zebra Mussel Infestation of Unionid Bivalves (Unionidae) in North America. American Zoologist 1996 36(3):300-310

Stewart, T. and J. Haynes. 1994. Benthic macroinvertebrate communities of southwestern Lake Ontario following invasion of *Dreissena* . *Journal of Great Lakes Research* **20**:479- 493.

Strayer, D.L., and Smith, D.R. 2003. *A guide to sampling freshwater mussel populations.* American Fisheries Society, Monograph 8, Bethesda, MD. 103 pp.

The National Native Mussel Conservation Committee. 1998. National strategy for the conservation of native freshwater mussels. J. Shellfish Res. 17(5):1419-1428.

Zanatta, D.T., Mackie, G.L., Metcalfe-Smith, J.L., and Woolnough, D.A. 2002. A refuge for native freshwater mussels *(*Bivalvia: Unionidae*)* from impacts of the non-native zebra mussel *(Dreissena polymorpha)* in Lake St. Clair. *J. Great Lakes Res*. 28(3):479- 489.

List of Figures

Figure 1. Numbers of freshwater mussel species found before and after the zebra mussel invasion at 13 sites in Lake Erie, Lake St. Clair, and the Niagara and Detroit Rivers (no "before" data available for 4 sites), and the locations of the four known refuge sites (Thompson Bay, Metzger Marsh, Nearshore Western Basin, and St. Clair Delta).

Source: Metcalfe-Smith, J.L., D.T. Zanatta, E.C. Masteller, H.L. Dunn, S.J. Nichols, P.J. Marangelo, and D.W. Schloesser (2002)

Last Updated

State of the Lakes Ecosystem Conference (SOLEC) 2008

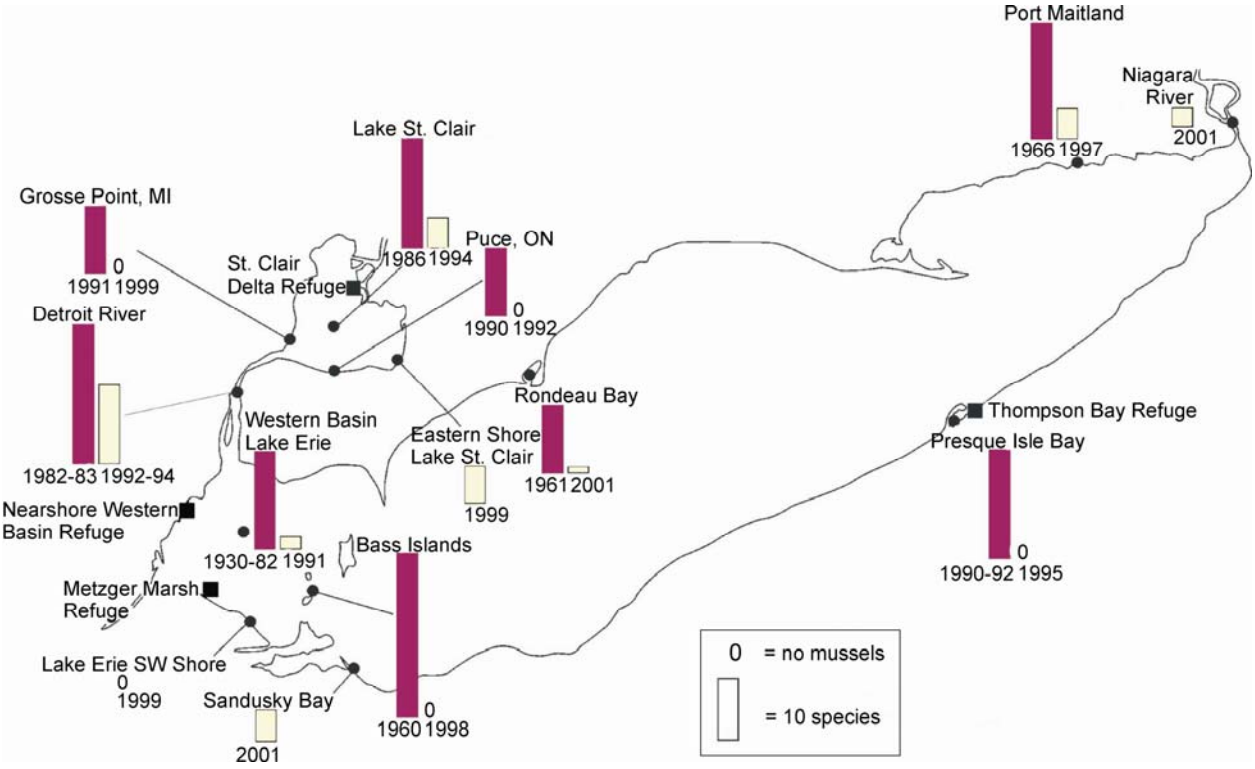

Figure 1. Numbers of freshwater mussel species found before and after the zebra mussel invasion at 13 sites in Lake Erie, Lake St. Clair, and the Niagara and Detroit Rivers (no "before" data available for 4 sites), and the locations of the four known refuge sites (Thompson Bay, Metzger Marsh, Nearshore Western Basin, and St. Clair Delta).
Source: Metcalfe-Smith, J.L., D.T. Zanatta, E.C. Masteller, H.L. Dunn, S.J. Nichols, P.J. Marangelo, and D.W. Schloesser (2002)