

2007 Great Lakes Aquatic Invasions Booklet

REFERENCES

Due to the nature of this publication, we were unable to cite specific reference materials within the text, however, this document should provide you the relevant information. Citations are sorted by section and page number, with the specific text from the publication preceding the corresponding reference material.

Great Lakes Aquatic Invasions - Page 3

“As of 2006, at least 200 non-native aquatic species have become established in the Great Lakes.”

Based on unpublished data; dependent on historical record-keeping and species criteria.

The total number of non-native species listed as being established (i.e. having a sustainable reproducing population) within the Great Lakes basin cannot be known with absolute precision, because of the following factors:

- 1) It is highly likely that there have been invasions by other species that have not yet been detected.
- 2) There are a number of species established in the Great Lakes whose origins are questionable. These species, termed cryptogenic, may have invaded centuries ago but their longterm presence in the basin causes them to be generally classified as native (many of these species are thought to have 'cosmopolitan' distributions). Similarly, some non-native species may have become established more recently, but are difficult to distinguish from native or other non-native species already present in the basin. This is especially likely for numerous invertebrate groups whose taxonomy is poorly known.
- 3) There have been a few non-native species found in the Great Lakes whose establishment is uncertain. Individuals have been introduced to the basin, perhaps multiple times, but may have failed to form sustainable populations. Alternatively, they may belong to small reproducing populations that have not yet been detected.

At the time of publication (March 2007), it was determined that the Great Lakes basin has been invaded by at least 185 non-native species, updating the information provided by Ricciardi (2006)*. Furthermore, there are at least 15 other species that are either cryptogenic or whose establishment is uncertain (A. Ricciardi, McGill University, personal communication, March 2007). Considering these potential invaders and the likelihood of additional undetected invasions, it seems probable that the true number of invaders in the Great Lakes basin exceeds 200 species.

*Ricciardi, A. *Patterns of invasion in the Laurentian Great Lakes in relation to changes in vector activity*. Diversity and Distributions (2006) 12, 425-433.

“This number continues to grow through vectors (mechanisms of AIS introduction and spread) such as maritime commerce, canals and waterways, organisms in trade, recreational activities, and public and private aquaculture.”

AIS Strategy and Appendix. *Great Lakes Regional Collaboration Strategy to Restore and Protect the Great Lakes*. <http://www.gllrc.us/strategy.html> and <http://www.gllrc.us/documents/strategy/AIS-Appendix.pdf>. December 2005.

“In one study, the economic and environmental losses caused by AIS in the Great Lakes have been estimated to be as much as \$5.7 billion annually.”

Pimentel, David. *Aquatic Nuisance Species in the New York State Canal and Hudson River Systems and the Great Lakes Basin: An Economic and Environmental Assessment*. Environmental Management, Vol. 35, No. 5, pp. 692-701. Published online May 17, 2005.

Protecting the Great Lakes from Global AIS Risks - Page 4

Transoceanic Graphic (full citation):

Maclsaac, Hugh J.; Kristen T. Holeck; Edward L. Mills; Margaret R. Dochoda; Robert I. Colautti; and Anthony Ricciardi. *Bridging Troubled Waters: Biological Invasions, Transoceanic Shipping, and the Laurentian Great Lakes*. BioScience, Vol. 54, No. 10, pp. 919-929 (11). October 2004.

"The Great Lakes basin is a unique ecosystem formed by a glacial process that began approximately 100,000 years ago."

Environment Canada. *How the Great Lakes were formed*. Movie.
<http://www.on.ec.gc.ca/greatlakeskids/GreatLakesMovie5.html>.

"The basin holds 90 percent of North America's surface freshwater..."

Mike Hoff. U.S. Fish and Wildlife Service. Personal Communication. 2006.

"...and supports more than 172 native fish species."

Jim Diana. University of Michigan. Personal Communication. 2007.

"The Great Lakes offer recreational enjoyment to more than 4 million registered boaters and 2 million anglers..."

AIS Strategy and Appendix. *Great Lakes Regional Collaboration Strategy to Restore and Protect the Great Lakes*. <http://www.gllrc.us/strategy.html> and <http://www.gllrc.us/documents/strategy/AIS-Appendix.pdf>.
December 2005.

"...which, along with commercial fishing, contribute to a fishery valued at over \$4 billion annually."

Great Lakes Fishery Commission. *Success of Sea Lampreys Control*.
<http://www.gllfc.org/sealamp/success.php>. (no date).

Consulted for general information:

Claudi, Renata and J.H. Leach, eds. *Nonindigenous Freshwater Organisms: Vectors, Biology, and Impacts*. CRC Press LLC, Boca Raton, Florida. 1999.

Case Study: Zebra Mussel (*Dreissena polymorpha*) – Page 5

"Rapidly spread by a variety of vectors, this non-native mollusk attaches to hard surfaces, including pipes and other submerged structures." – and – "Zebra mussels are efficient filter feeders..." – and – "Costly recreational impacts associated with zebra mussels include the sharp shells littering Great Lakes beaches..."

National Atlas of the United States® (U.S. Geologic Survey). *Article: Zebra Mussels*. http://www-atlas.usgs.gov/articles/biology/a_zm.html. Last modified June 28, 2005.

"Biodiversity of the Great Lakes ecosystem has been devastated by zebra mussel colonization as evidenced by declines in native clam populations..."

U.S. Geological Survey Great Lakes Science Center. *Zebra Mussel*.
http://www.gllsc.usgs.gov/main.php?content=research_invasive_zebramusel&title=Invasive. Last modified August 10, 2004. - and - National Atlas of the United States® (U.S. Geologic Survey). *Article: Zebra Mussels*. http://www-atlas.usgs.gov/articles/biology/a_zm.html. Last modified June 28, 2005.

"...and the collapse of forage populations, such as the shrimplike amphipod Diporeia. By depleting the base of the food web, zebra mussels can impact important fish species such as trout and salmon."

National Oceanic and Atmospheric Administration Great Lakes Environmental Research Lab. *Great Lakes Fish Community Impacted by Diporeia Disappearance?*. <http://www.glerl.noaa.gov/pubs/brochures/dipo-fish/dipo-fish.html>. 2000.

“...and the proliferation of the often toxic blooms of the blue-green algae *Microcystis*.”

Vanderploeg, H. *The Zebra Mussel Connection: Nuisance Algal Blooms, Lake Erie Anoxia, and other Water Quality Problems in the Great Lakes, Microcystis Blooms Return*. National Oceanic and Atmospheric Administration Great Lakes Environmental Research Lab.

<http://www.glerl.noaa.gov/pubs/brochures/mcystisflyer/mcystis.html>. 2002.

Case Study: Sea Lamprey (*Petromyzon marinus*) – Page 6

“By the late 1940s sea lamprey had contributed to the decline of several fish species including lake trout, with catch decreasing from 15 million pounds in the upper Great Lakes to only 300,000 pounds by the 1960s.”

Great Lakes Fishery Commission. Fact Sheet #3: *Sea Lamprey: A Great Lakes Invader*. 1998.

“...\$4 billion Great Lakes commercial and recreational fisheries..” - and - “...reducing sea lamprey populations by 90 percent in many areas.”

Great Lakes Fishery Commission. *Success of Sea Lampreys Control*.

<http://www.glfsc.org/sealamp/success.php>. (no date).

“Current research is focused on trapping sea lamprey populations with applications of sea lamprey pheromones. Also under investigation is use of these hormones to disrupt normal sea lamprey spawning.”

Marris, Emma. *Fish Pheromones Made in Lab*. MacMillan Publishers Ltd.

<http://www.bioedonline.org/news/news.cfm?art=2056> (BioEd Online). October 2, 2005.

Case Study: Hydrilla (*Hydrilla verticillata*) – Page 7

“Hydrilla, a potential Great Lakes invader, was first introduced into U.S. waters as an aquarium plant in Florida during the 1950s.”

Western Aquatic Plant Management Society. *Hydrilla verticillata*. <http://www.wapms.org/plants/hydrilla.html>. Last updated June 16, 2004.

“With each fragment capable of growing up to one inch per day, dense mats of hydrilla can quickly form, shading out beneficial native species.”

Langeland, K.A. *Hydrilla verticillata* (L.F.) Royle (Hydrocharitaceae), *The Perfect Aquatic Weed*. Castanea 61:293-304. <http://aquat1.ifas.ufl.edu/hydcirc.html>. (Center for Aquatic Plants University of Florida). 1996.

Case Study: Bighead (*Aristichthys nobilis*) and Silver carp (*Hypophthalmichthys molitrix*) – Page 8

“Bighead and silver carp, potential Great Lakes invaders, were imported into the United States in the early 1970s for the purpose of controlling weeds in public and private aquaculture ponds in the lower Mississippi River. Flooding in the early 1990s led to the escape of thousands of Asian carp into the Mississippi River, allowing a northward migration toward the Great Lakes.”

U.S. Environmental Protection Agency. *Asian Carp and the Great Lakes*.

<http://www.epa.gov/glnpo/invasive/asiancarp>. Last updated October 15, 2004.

Case Study: Purple loosestrife (*Lythrum salicaria*) – Page 9

“An estimated 190,000 hectares of wetland, marshes, pastures and riparian meadows are invaded by purple loosestrife in North America each year...”

Minnesota Sea Grant. *Purple loosestrife: What you should know, what you can do*.

<http://www.seagrant.umn.edu/exotics/purple.html>. Last modified Nov. 4, 2004.

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