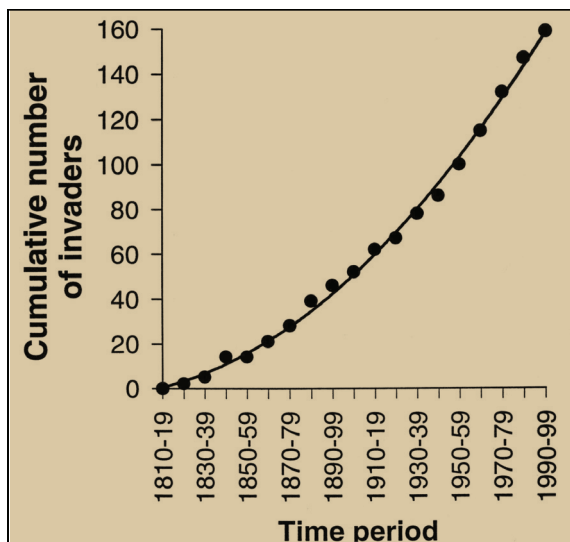


Aquatic Invasive Species (AIS) and the Great Lakes: Simple Questions, Complex Answers

How many aquatic nonindigenous species are there in the Great Lakes?

The earliest record of an aquatic species invasion in the Great Lakes is the sea lamprey, first entering the Great Lakes from the Atlantic Ocean via the Erie Canal during the 1820s. Extensive literature reviews have documented 162 aquatic nonindigenous aquatic species established in the Great Lakes as of 2000, representing fishes, invertebrates, aquatic plants, algae, and pathogens. This number is best interpreted as a minimum. Identification depends on our ability to find, recognize, verify, and document new species, which is, in turn, dependent on our ability to sample the system, and how often.



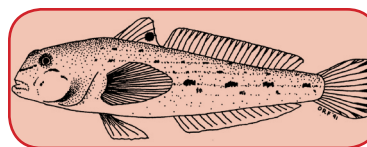
The record of nonindigenous species established in the Great Lakes in 10-year intervals since 1810. The rate of new invasions has been almost constant since about 1950, and the total is now at least 162 (Ricciardi, 2001).

The Great Lakes basin is the aquatic gateway to the heartland of North America and a hot spot for aquatic species introductions to major interior sections of the U.S. and Canada. Nonindigenous species pose one of the most serious and difficult threats to the Great Lakes today.

How are nonindigenous species getting into the Great Lakes?

Ships' ballast tanks were the major vector for nonindigenous species introductions to the Great Lakes during the latter half of the 20th century. From 1959, when the St. Lawrence Seaway opened, through 2000, 36 of 50 nonindigenous aquatic species established in the Great Lakes are attributed to ballast tank transport and discharge of untreated ballast water. New evidence suggests that the residual water and mud found in many "empty" ballast tanks (i.e., no-ballast-on-board" or "NOBOB" tanks) is also a potential source for some species invasions. Hull fouling is not thought to be a significant vector for new introductions to the Great Lakes, because most freshwater fouling organisms would not survive prolonged exposure to salt water during transoceanic voyages.

Unintentional releases have made the second highest contribution of nonindigenous aquatic species to the Great Lakes. This includes escape from aquaculture sites and the aquarium and bait trades. Canals connecting watersheds and river systems were responsible for some significant historical introductions of exotic species such as sea lamprey and alewife. Presently (Sept 2002), the Chicago Sanitary and Ship Canal, which connects the Mississippi River system with Lake Michigan, is being watched with great concern as a probable route for three Asian carp species (silver, black, and bighead) moving up the Mississippi River system. These species are considered a major threat to the biological integrity of the Great Lakes.



Where are these organisms (species) coming from?

By far, the majority of aquatic species that have invaded the Great Lakes are native to Eurasia. More recently, species native to the Ponto-Caspian basins (Black, Caspian, and Azov Seas) of eastern Europe have been remarkably successful in the Great Lakes. Of 11 ballast-implicated invasions since 1986, 8 are by Ponto-Caspian species. Prominent among Ponto-Caspian invaders are zebra mussels, quagga mussels, round gobies, fishhook waterfleas and *Echinogammarus* amphipods. These Ponto-Caspian taxa now constitute a very significant component of the biomass and productivity of Great Lakes' food webs.

Coastal North Atlantic is the second largest known source for nonindigenous species in the Great Lakes, although it ranks far behind Eurasia. Examples of AIS from this region include sea lamprey, alewife, and blueback herring.

What effect are these organisms having on the Great Lakes?

There have been major negative impacts on the Great Lakes ecosystem that appear to be directly, and indirectly, linked to the establishment of AIS. These impacts have appeared at every level of the food web and are affecting both the commercial and recreational resources for which the Great Lakes are best known. Examples include:

- ❖ Loss of the native lake trout population in the early 1900s attributed to the sea lamprey.
- ❖ The remarkable improvement in water clarity, especially in Lake Erie, representing rapid removal of the “pelagic” (i.e., water column) food base by zebra mussels.
- ❖ The disappearance from Lakes Michigan, Huron, Erie, and Ontario of a small shrimp-like invertebrate called *Diporeia* (pronounced “Die poor eye ah”) which has been in the Great Lakes since their formation at the end of the Ice Age.
- ❖ Native clam and mussel populations dramatically declined due to zebra mussels.
- ❖ Poor body condition of lake whitefish, a commercially valuable fish in the Great Lakes, probably due to the decline in *Diporeia* (the primary food for lake whitefish).
- ❖ Declines in the yellow perch population in Lake Michigan appear to be associated with one or more invasive species, and increased frequency of toxic algal blooms (*Microcystis*) in the Great Lakes, apparently associated with zebra mussels.
- ❖ Clogging of fishing nets by the fishhook water-flea increases costs for commercial fishermen.

If any of the Asian carp (see front page) become established in the Great Lakes, even more food web disruptions are anticipated since bighead and silver carp are voracious feeders on plankton and black carp consume mollusks and crustaceans.



Zebra mussels attach to the shells of native mussels, prohibiting them from feeding.

What is GLERL Doing in Regard to Invasive Species?

The Great Lakes Environmental Research Laboratory is NOAA's leading institution for aquatic invasive species research and is mandated by law (P.L. 104-332; 16 U.S.C. § 4701 et seq.) to conduct such research.

GLERL's research targets two critical areas related to invasive species: (1) prevention and control to stop the inflow and spread of new aquatic organisms, particularly via ship ballast, and (2) minimizing ecological and economic impacts of species invasions by developing the fundamental ecosystem understanding needed for adaptive management strategies. GLERL's current research program includes: assessment of NOBOB vessels, effectiveness of chemical biocides, effects of new invaders on Great Lakes food web, effects of food web changes on Great Lakes living resources, and effects of zebra mussels on nearshore habitat.

Partnerships and scientific collaborations are an important component of GLERL's research programs. Invasive species research partners include scientists at the University of Michigan (Cooperative Institute for Limnology and Ecosystems Research; Dept. of Naval Architecture and Marine Engineering), University of Windsor (Great Lakes Institute for Environmental Research), Old Dominion University (Dept. of Ocean, Earth, and Atmos. Sciences), Smithsonian Environmental Research Center, Great Lakes Fishery Commission, Michigan State University, University of Maryland (Chesapeake Biological Laboratory), Illinois Natural History Survey, University of Minnesota, and University of Wisconsin.

GLERL represents NOAA on the Great Lakes Panel on Aquatic Nuisance Species and has actively served on that panel since its inception. GLERL scientists served on various committees of the National Invasive Species Council to help develop the National Invasive Species Management Plan. All of GLERL's current research on invasive species falls within the priorities set by the Aquatic Nuisance Species Task Force and builds directly on the National Management Plan. GLERL scientists also interact with the International Joint Commission and the International Association for Great Lakes Research as well as other Federal and state agencies on invasive species issues.

For more information on this or other GLERL research projects, please contact: GLERL Information Services, 2205 Commonwealth Blvd., Ann Arbor, MI 48105, 734-741-2262. Or visit our web site at: www.glerl.noaa.gov.