OUR WATERS

The waters of Southeastern Wisconsin are vast but vulnerable.
We depend on our waters for drinking water, irrigation, industry, transportation, power production, recreation and scenic beauty.
Understanding our region's water-related issues and future challenges can help us protect clean, abundant water for generations to come.

Lake Michigan's Food Web

Food Web Basics

A *food web* is the interconnected feeding relationships among species in an ecosystem. A food web cycles material and energy through Lake Michigan's living organisms. For example, algae converts sunlight to food energy and is consumed by tiny animals, small fish, predators, and eventually decomposers.

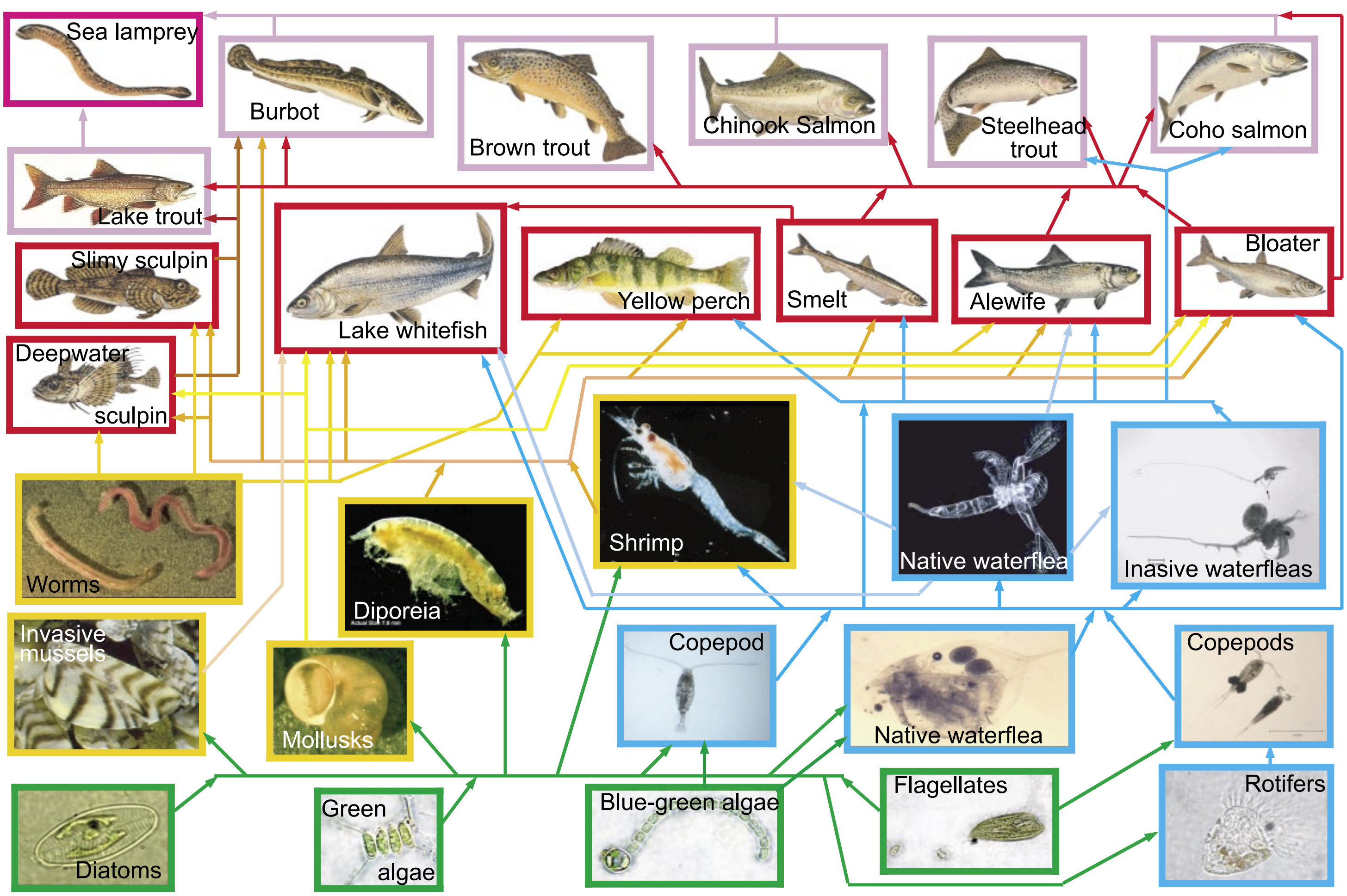
Predatory fish - Fish that feed primarily on other fish

Prey fish - Small fish that typically produce many offspring and serve as food for predatory fish

Macroinvertebrates - Invertebrate animals that are visible to the naked eye and serve as food for prey fish

Zooplankton - Microscopic invertebrates that serve as food for macroinvertebrates and prey fish.

Phytoplankton - Microscopic photosynthetic organisms that serve as food for macroinvertebrates and zooplankton.



Source: NOAA Great Lakes Environmental Research Laboratory, food web based on model constructed for "Impact of Exotic Invertebrate Invaders on Food Web Structure and Function in the Great Lakes: a Network Analysis Approach" by Mason, Krause, and Ulanowicz, 2002.

Food Web Changes

Changes in Lake Michigan's ecosystem from pressures like invasive species, overfishing, nutrient pollution, or changing climates can impact many species through the complex food web. Although a problem might initially affect one population, cascading "top-down" and "bottom-up" effects occur.

Top-down Effects: changes in one population that affect species lower in the food web

Chinook salmon

• Stocked in Lake Michigan beginning in 1965 along with other predatory fish, partly to control nuisance alewife

Alewife

• Predation controls high alewife numbers thought to interfere with yellow perch reproduction in the 60s and 70s.

Yellow perch

• Yellow perch abundance increases in the 80's, partly due to reduced alewife population

Bottom-up Effects: changes in one population that affect species higher in the food web

Invasive mussels

• Zebra mussels and quagga mussels invade Lake Michigan in 1989 and 1997 and continue to spread

Diporeia

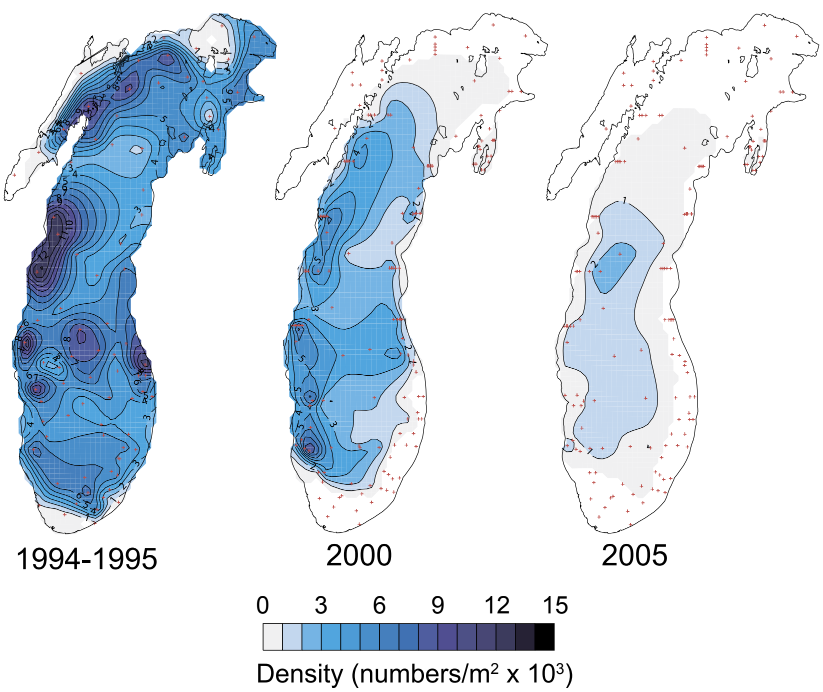
• Severe declines in *Diporeia* densities in the 90's may be linked to the spread of invasive mussels

Lake whitefish

• Recent declines in whitefish condition may be related to scarcity of *Diporeia,* the favored food of whitefish

Macroinvertebrates

Diporeia Density in Lake Michigan



Source: NOAA Great Lakes Environmental Research Laboratory, "The Impact of Diporeia Spp. Decline on the Great Lakes Fish Community."

This figure shows *Diporeia* density based on sites (marked with red) that were monitored over time. Scientists used a Ponar dredge, an instrument that is lowered on a cable to the lake bottom, to collect sediment and organisms at each site.

In recent years scientists have observed an unprecedented decline in ***Diporeia*** in Lake Michigan.

Diporeia are an important food source for lake whitefish and many prey fish. The small (less than ½ inch) crustaceans live on the lake bottom in deep areas of the Great Lakes. Their decline could affect many fish in the food web through bottom-up effects.

Historically, most deep parts of Lake Michigan supported several thousand *Diporeia* per square meter. *Diporeia* have disappeared from much of the northern and southeastern parts of the lake, and the decline has progressed from shallow to deeper waters.

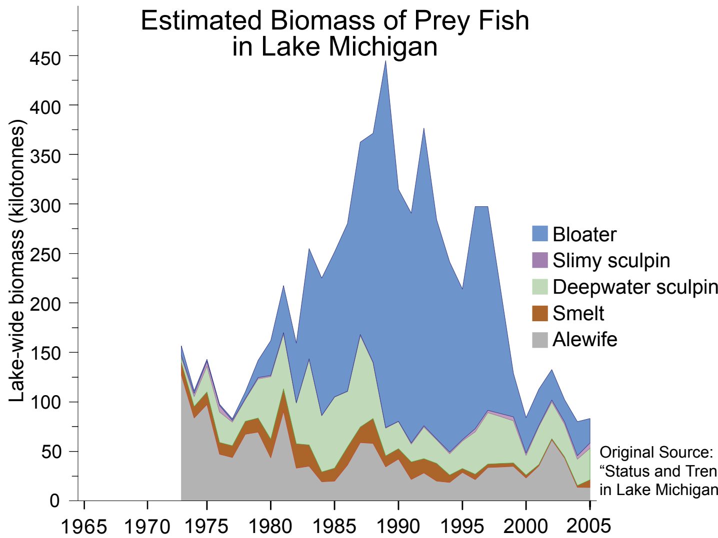
Severe declines in *Diporeia* density since the 90's are potentially linked to the spread of invasive mussels. Although this connection is not yet understood, scientists suspect that mussels negatively impact *Diporeia* due to food competition (for plankton settling from the surface), or feces and other wastes.

Prey Fish

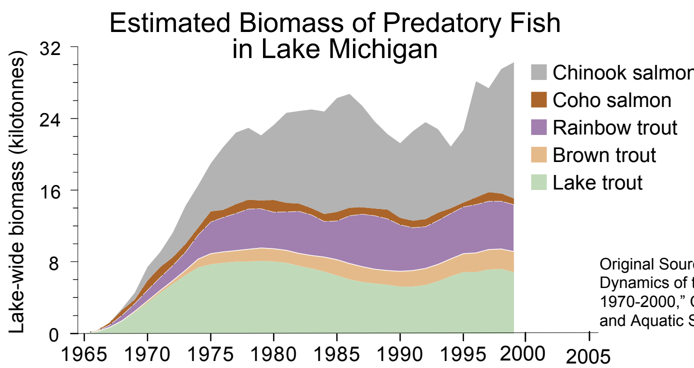
The **alewife**, an invasive species from the Atlantic, entered Lake Michigan through shipping canals. When lake trout numbers plummeted in the 50's, the lack of predators allowed alewife numbers to boom.

Huge alewife die-offs occurred in the 60's due to the species' high numbers and poor adaptation to freshwater. Alewife also interfered with the reproduction of some native species. Salmon and trout were stocked in the lake beginning in 1965 to control alewife.

Alewife are still a common prey fish and may cause a thiamine deficiency in the eggs of lake trout that feed extensively on them. The vitamin deficiency reduces hatching and survival rates.



Original Source: Madenjian and others, "Status and Trends of Prey FIsh Popula in Lake Michigan, 2005," USGS.



Original Source: Madenjian and others, Dynamics of the Lake Michigan food we 1970-2000," Canadian Journal of Fisher and Aquatic Sciences 59:736-753, 2002

These graphs show the total mass and major species of prey fish (top) and predatory fish (bottom) over time in Lake Michigan.

Salmon and trout stocking reduced problem alewife numbers and allowed populations of some native prey fish to recover.

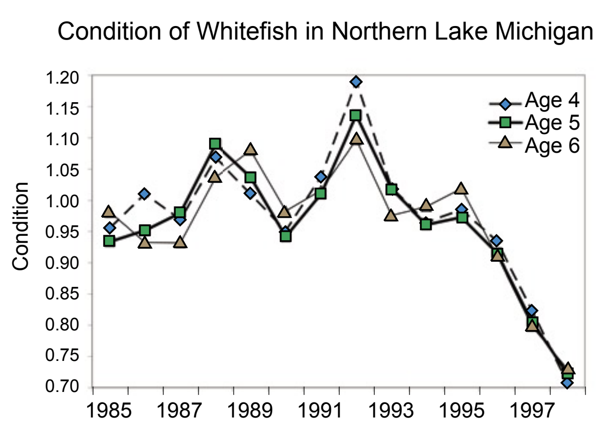
From 1989 to 1997, the numbers of young **yellow perch** surviving to join Lake Michigan's breeding population were low. This caused a decline in the species, possibly related to ecosystem changes including the invasion of zebra mussels and changes in seasonal temperature and weather conditions.

The commercial yellow perch fishery was closed in 1996, and sport fishing is prohibited during the species' spawning season.

There have been varied signs of yellow perch recovery. A strong year of perch spawned in 1998 has helped boost the population and support the sport fishery. Fisheries surveys showed high numbers of perch hatched in 2005, but their impact on the population won't be known for another year.

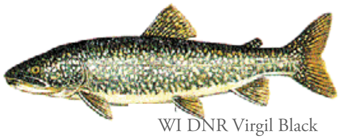
The health of **lake whitefish**, the most important commercial fishery in Lake Michigan, has declined in the last two decades. Whitefish condition (a ratio of weight to length), and lengths and weights at standard ages have decreased. Whitefish numbers and commercial catch, however, have remained high, with about 1.5 million pounds harvested annually.

Since lake whitefish feed on *Diporeia*, their poor condition may be related to the declining densities of this invertebrate. A scarcity of *Diporeia*, which are high in calories and fats, may cause whitefish to compete for a limited food source or to depend on less nutritious prey such as invasive mussels.



Source: Schneeberger, P. and others, "Status of Lake Whitefish in Lake Michigan," Technical Report 66 of the Great Lakes Fishery Commission, 2005.

Predatory Fish



Lake trout are Lake Michigan's top native predator, and the lake once held the largest population of the species in the world. Diverse genetic varieties, or strains, used different habitats and food sources and helped stabilize the food web.

Natural populations of lake trout disappeared from the lake by the early 1950's, devastated by overfishing and predation by the invasive sea lamprey.

The U.S. Fish and Wildlife Service stocks an average 2.4 million lake trout annually in Lake Michigan. The stocked fish survive well, but natural reproduction and survival of wild eggs to adulthood has been negligible.

Invasive species may be impeding lake trout recovery. Sea lamprey numbers, despite controls, are slowly rising in Lake Michigan. Alewives are fed on by lake trout and may cause a vitamin deficiency in trout eggs that reduces hatching and survival. Alewives and round gobies may also feed on eggs and larvae.

Other barriers to lake trout recovery could be the relatively low numbers of lake trout stocked, characteristics of the strains stocked, or the locations they are stocked in Lake Michigan.

A drafted restoration plan for Lake Michigan lake trout, developed by an interagency technical committee, will focus future stocking on two offshore refuge areas where lake trout historically spawned. In the refuges, trout are protected from fishing, and invasive species are less abundant. Lakewide research helped the committee recommend certain strains for stocking that survive well in Lake Michigan and are less vulnerable to lamprey.

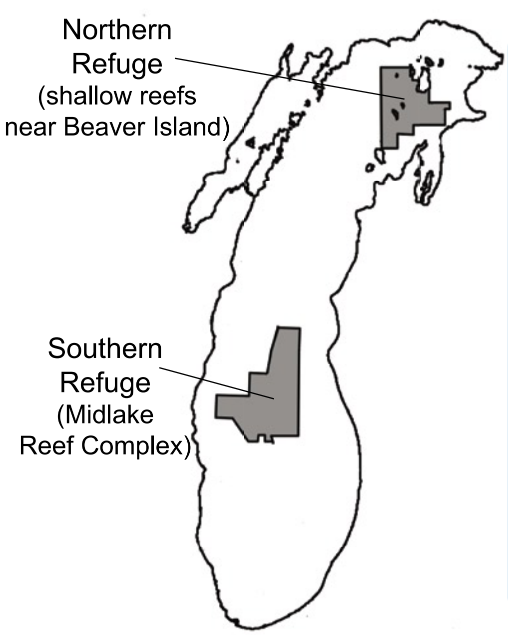
Chinook salmon are stocked annually along with Coho salmon, lake trout, rainbow trout and brown trout. The stocked predator fish curtailed alewife numbers and helped establish a $4.5 billion sport fishery in the Great Lakes. About a third of Great Lakes anglers fish on Lake Michigan.

The invasive **sea lamprey** arrived in Lake Michigan in 1936, after swimming through shipping canals from the Atlantic.

Sea lampreys attach to fish and feed on their body fluids, wounding and sometimes killing victims. Lamprey severely impacted native populations of lake whitefish and contributed to the loss of Lake Michigan lake trout.

Current methods of lamprey control include traps and the use of a "lampricide" poison in streams where they spawn (it does not harm other species).

Lake Trout Refuge Areas in Lake Michigan



One strain of lake trout stocked in Lake Michigan is actually descended from the lake's native trout.

In 1889, lake trout were transported by rail and pack mule from northern Lake Michigan to Yellowstone National Park where they were stocked in two mountain lakes. When Lake Michigan's lake trout crashed, Yellowstone safeguarded this remnant population. Today, lake trout reared from eggs collected in Yellowstone's Lewis Lake are stocked in Lake Michigan.

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Find more information online at **www.glwi.uwm.edu/ourwaters** or e-mail **our-waters@uwm.edu.**

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