Changes in Lake Huron's Ecosystem and Foodweb cause Chinook salmon collapse Summer 2010

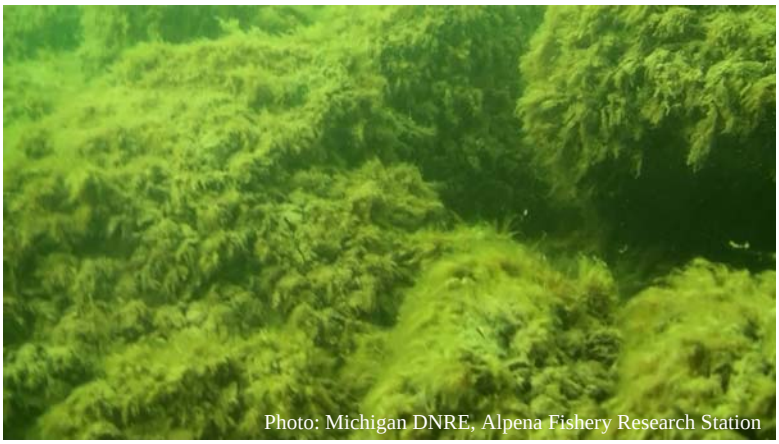
A recent wave of invasive-species (zebra and quagga mussels and round gobins) is wrecking havoc on the quality and character of Lake Huron's valuable recreational and commercial fisheries. The ecosystem changes are being driven (principally) by 6 evidently permanent changes in the foodweb:

1. Colonization by new invasive species: Zebra and, more recently, quagga mussels –interlopers from the Caspian Sea - have trapped much of the lake's productivity in mussel colonies on the lake bottom. These huge colonies act as nutrient "sinks", where high biomass – tons upon tons of mostly quagga mussels - has accumulated that cannot be efficiently channeled to the rest of the food chain. Mussel colonies appear to have caused productivity to shift from plankton (which many fish rely upon for food) in the water column to invasive mussels (which most fish cannot eat) at the bottom of the lake, or the "benthic zone", particularly in shallow bays and nearshore areas. Production of fish and the plankton they feed upon in offshore waters known as the "pelagic zone", where alewives and salmon once thrived, is now only a fraction of levels prior to 2003.

Zebra and quagga mussels are trapping nutrients on the bottom of Lake Huron.

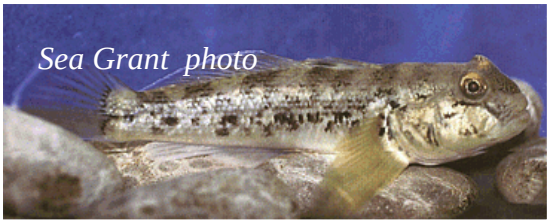
2. Dreissenid mussels, in addition to their role as nutrient traps, have cleared the water by removing most particulate matter. As a result sunlight penetrates much deeper than it used to. The benthic algae, *Cladophora*, and other bottom algae,

have capitalized on the combination of plentiful nutrients and sunshine on the lake's bottom and carpeted the lake bed with mats that resemble dirty green shag carpeting. These carpets come loose, especially in late summer, and can pile up on beaches forming a black or gray "gunk" that smells bad and is repulsive to beach combers, especially the bare footed kind.



Cladophora **is a filamentous alga that flourishes in mussel colonies, but is not consumed by other aquatic organisms. Cladophora is thus a "dead end"; nutrients locked up in these algae beds are not available to the food web.**

3. The mussel invasion paved the way for another invader from the Caspian, the round goby, a bottom-oriented fish that evolved with zebra and quagga mussels. The round goby feeds on small mussels and other invertebrates, fish eggs and small fish associated with mussel colonies. As with the mussels, round gobies reached the Great Lakes through ballast water discharges of salt water vessels.



The round goby is another invader, specially adapted to living with mussel colonies

4. Biologists are alarmed at the near disappearance of a crustacean called Diporeia. This shrimp-like animal feeds on plankton that settles to the bottom. Diporeia migrate off the bottom at night making them available as prey for such fish as alewives and whitefish. Diporeia thus acted as a mechanism for recycling settled nutrients back to the midwater pelagic foodchain, and were a staple in the diets of alewives and Chinook salmon. Although the mechanism for the collapse of Diporeia is not clear, their demise came closely on the heels of the zebra and quagga mussel invasions.

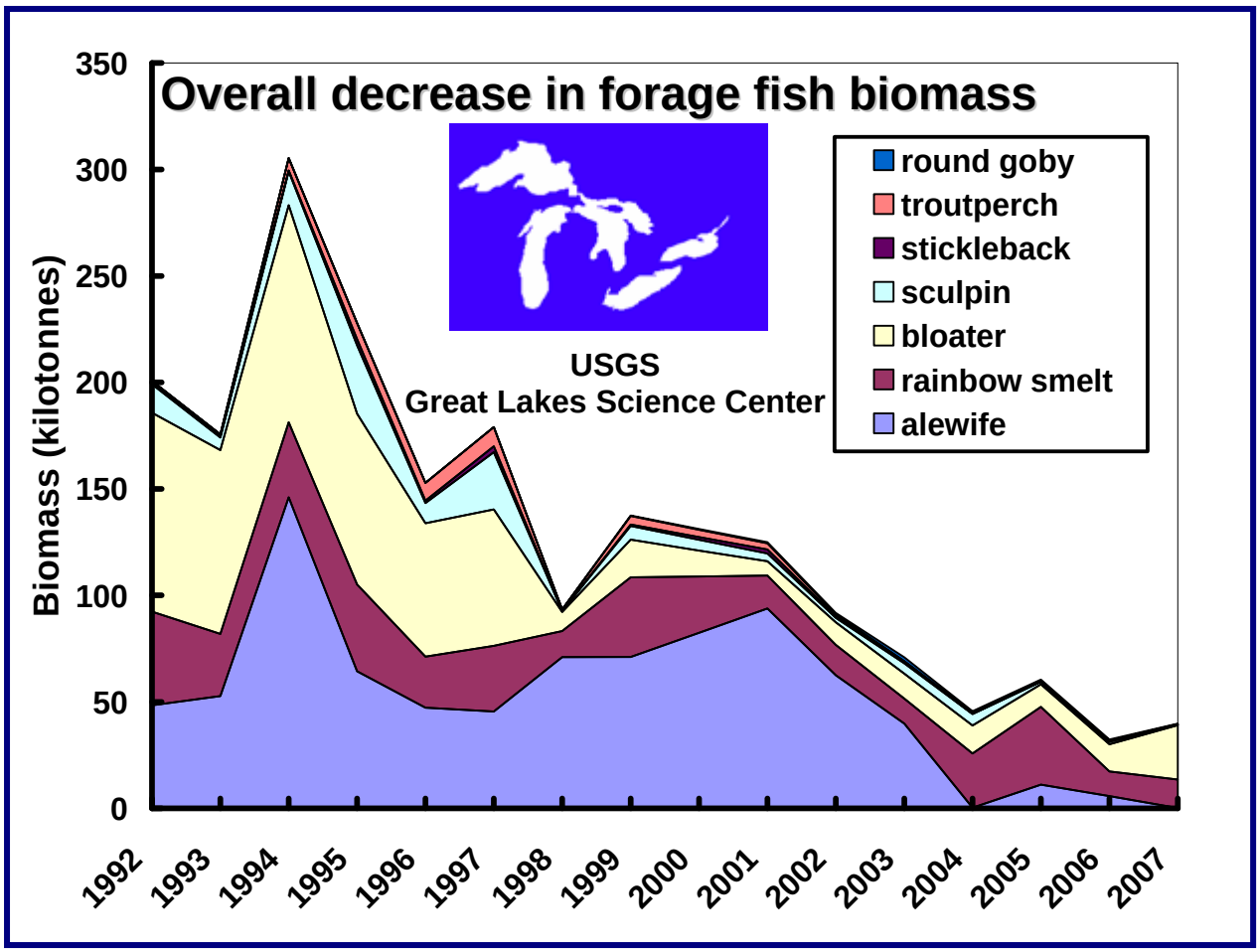
Diporeia – victim of invasive species?

More recently, the Environmental Protection Agency noticed a sharp decline in abundance of other planktonic foods preferred by alewives. Plankton abundance since 2003 in the offshore waters of Lake Huron has recently been described as similar to that of Lake Superior – the least productive lake of the Laurentian Great Lakes. This represents a distinct reduction in offshore food resources for pelagic prey fish like alewives.

5. Reproduction of Chinook salmon rose sharply after 1992. Approximately 80% of Lake Huron's Chinooks born in 2000, 2001, 2002, and 2003 were wild (see trout and salmon publications: "*Mass-marking reveals emerging self regulation of the Chinook salmon population in Lake Huron*"). Survival of hatchery Chinooks declined sharply as reproduction rose. Almost all Lake Huron's Chinook reproduction is in Ontario's tributaries to Georgian Bay and North Channel. Consequently, as Chinooks mature they tend to leave Michigan waters of Lake

Huron in late summer to spawn in their natal streams in Ontario. High numbers of these Canadian-born wild salmon (perhaps as many as 18,000,000 juveniles per year) caused predation rates on Lake Huron's alewives to rise.

6. Thus the alewife population, caught between rising predation from a reproducing Chinook salmon population and starvation rations caused by collapse of plankton, almost disappeared in 2003-2004. And so did most other prey fish species. Alewives had been the chief prey of Chinook salmon in the 1990s. Chinook salmon were unable to shift their diets to the now abundant round goby, leading to disastrous consequences for Lake Huron's once famous Chinook salmon recreational fishery.

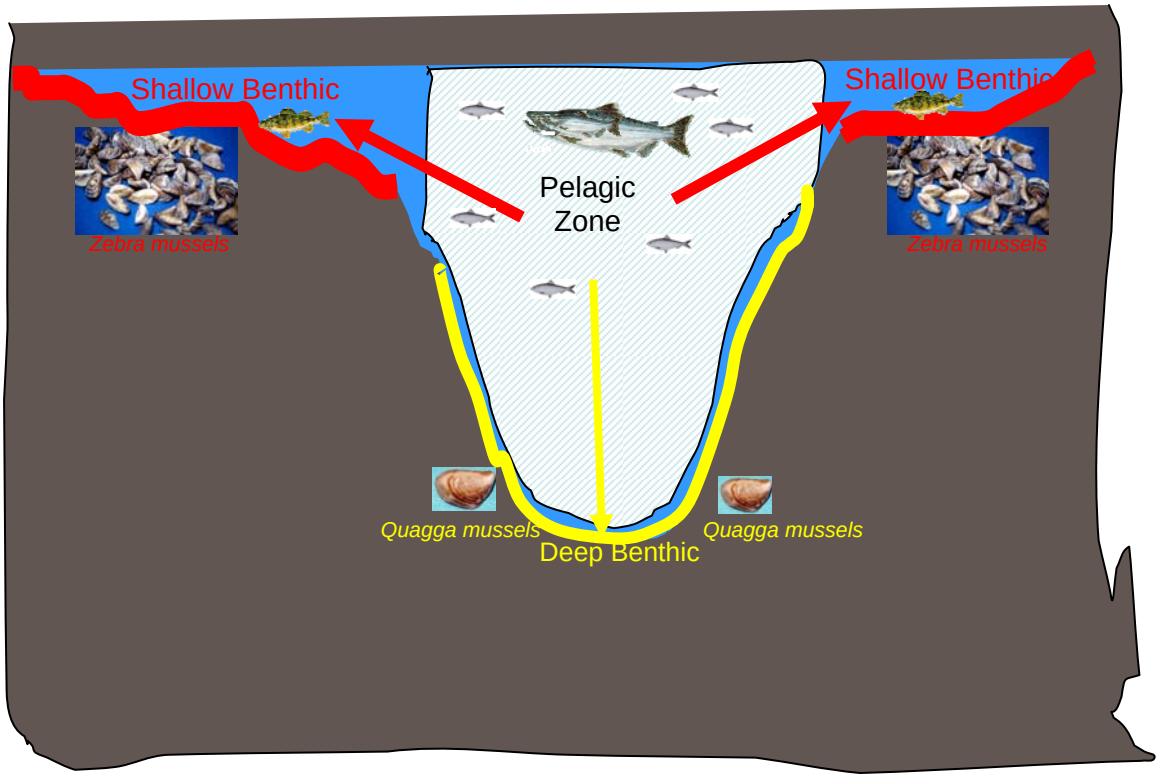


Trends in prey fish biomass, Lake Huron. Caught between the effects of zebra and quagga mussels and rising predation rates, alewives collapsed. ***Courtesy of United States Geological Survey, Great Lakes Science Center, Ann Arbor.***

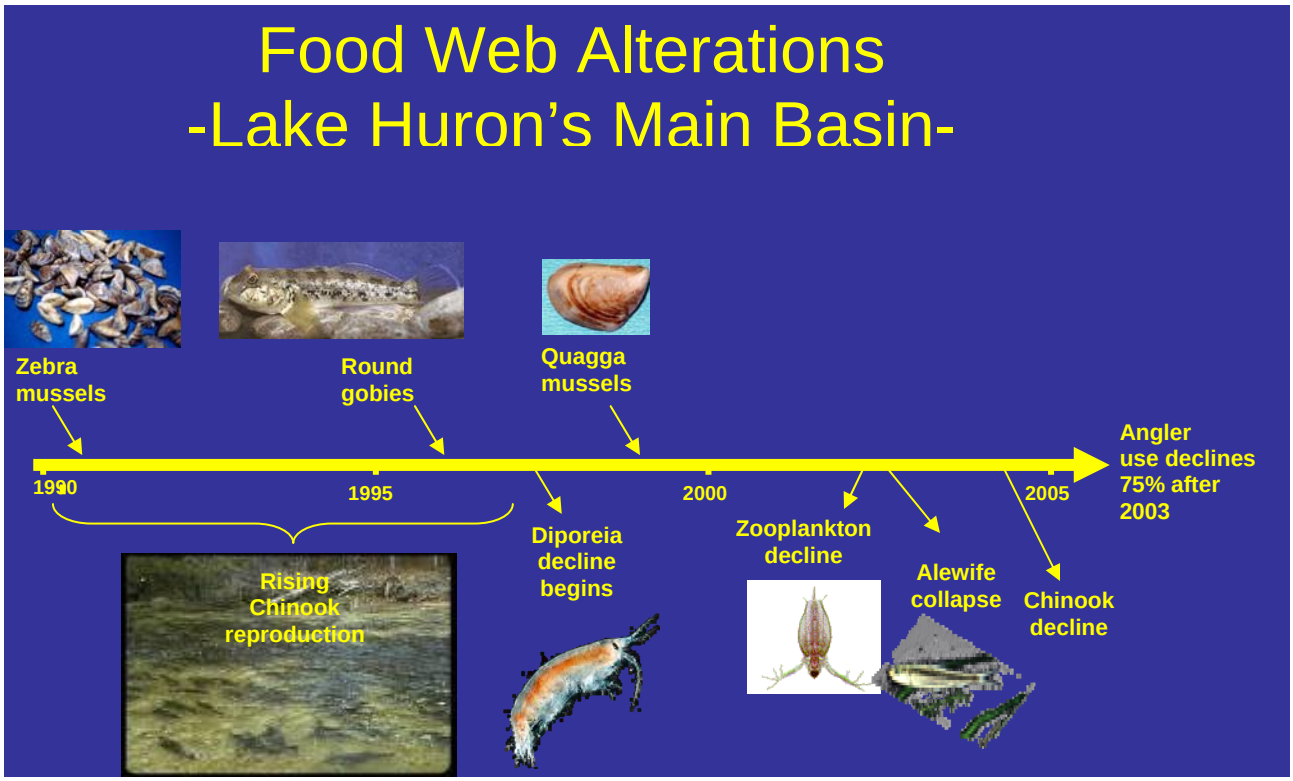
There were other factors involved. Lake trout are surviving better as a result of: 1) more effective sea lamprey control; and 2) increased protection of lake trout from commercial fishing under terms of the 2000 Consent Decree with Treaty of 1836 tribes. Thus, predation rates from lake trout have also risen. However, the above are six leading factors that precipitated the changes anglers are now witnessing.

Economic impacts of the decline in salmon on Lake Huron's Main Basin coastal communities have been considerable.

Lake Zones



Production zones. Production in Lake Huron has shifted from the pelagic zone, where alewives and Chinooks once predominated, to the benthic zone. Near-shore benthic production is represented in red and is where both zebra and quagga mussels have proliferated. Deep-benthic production, represented with yellow, is where quagga mussel are now abundant.



Time line representing the sequence of major changes to Lake Huron's foodweb caused principally by invasive species.

The new ecosystem:

Change is never welcome especially when people are happy with the status quo. Until 2003, Chinook salmon success rates (fish harvested per angler day) on Lake Huron were among the highest of Michigan's Great Lakes. Now, with the near disappearance of alewives, we are seeing the following new conditions:

1. **Chinook recreational harvest** (Figure 1) declined 91% after the alewife collapsed in 2004. With prospects for catching Chinook so low, fishing pressure at major Chinook fishing ports declined 75% (Figure 2), with serious economic consequences to tackle shops and other elements of the recreational fishing industry. The decline in Chinook harvest has cost 10 major Lake Huron Chinook salmon fishing ports in Michigan a minimum of $19 million in lost economic activity each year since 2004.

2. **Chinook condition** (plumpness) reached the lowest ever measured in Great Lakes salmon shortly after the 2003-04 alewife collapse. Three-year-old salmon that once averaged over 15 pounds weighed only 7.9 pounds in 2005 (Figure 3). Most Chinook salmon observed since 2003 had empty stomachs. Some fish were visibly emaciated (Figure 4). Chinook salmon size has recovered considerably since 2005 (Figure 3), but numbers of Chinook, both of hatchery and wild origin, remain very low.

3. **Chinook population decline:** It appears lack of food caused adult salmon and other predators to feed on young salmon, thus leading to a sharp drop in the Chinook population. Prior to 2003, predators were too busy eating the massively abundant alewives to bother taking stocked and wild juvenile salmon. When the alewives collapsed, stocked fish became food for fish that were already there. Unfortunately, during their first year in Lake Huron, juvenile Chinook salmon are the same size and color as alewives and they occupy the same area of the lake as alewives, which makes them especially vulnerable to predators. For more information on factors affecting survival of Chinook salmon see: *Investigations into causes of variable survival of Chinook salmon stocked into Lake Huron.*

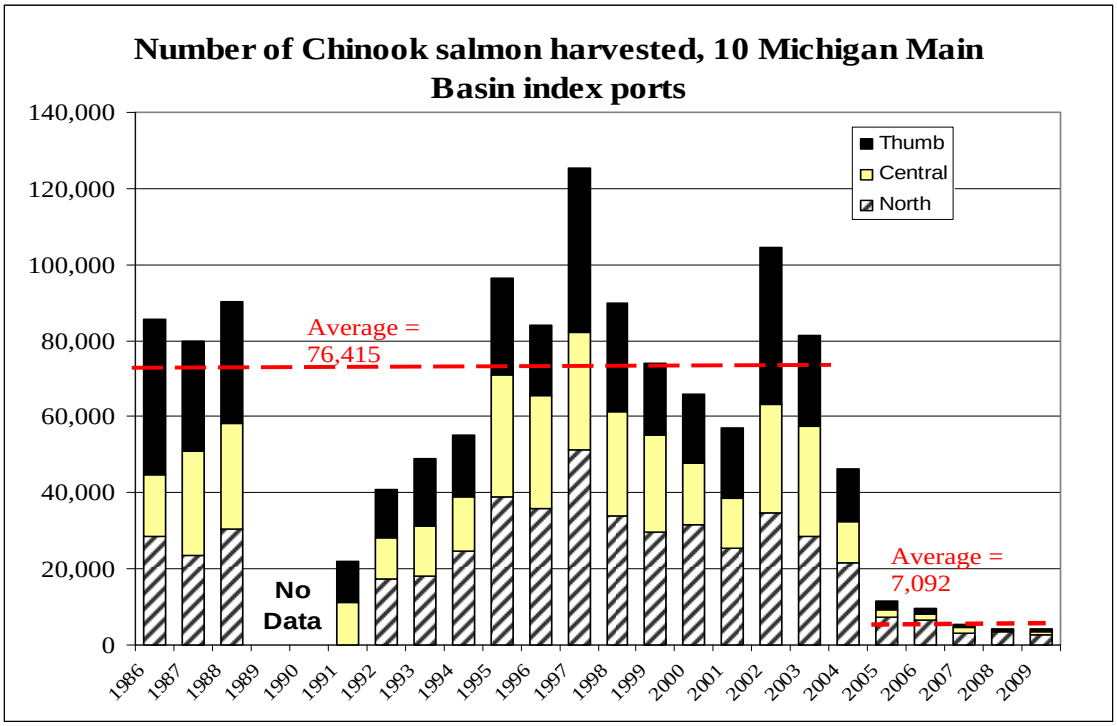


Figure 1. Trends in Chinook harvest at 10 Main Basin index ports. Lake Huron. Harvest since 2004 was less than 10% of the pre-2004 average.

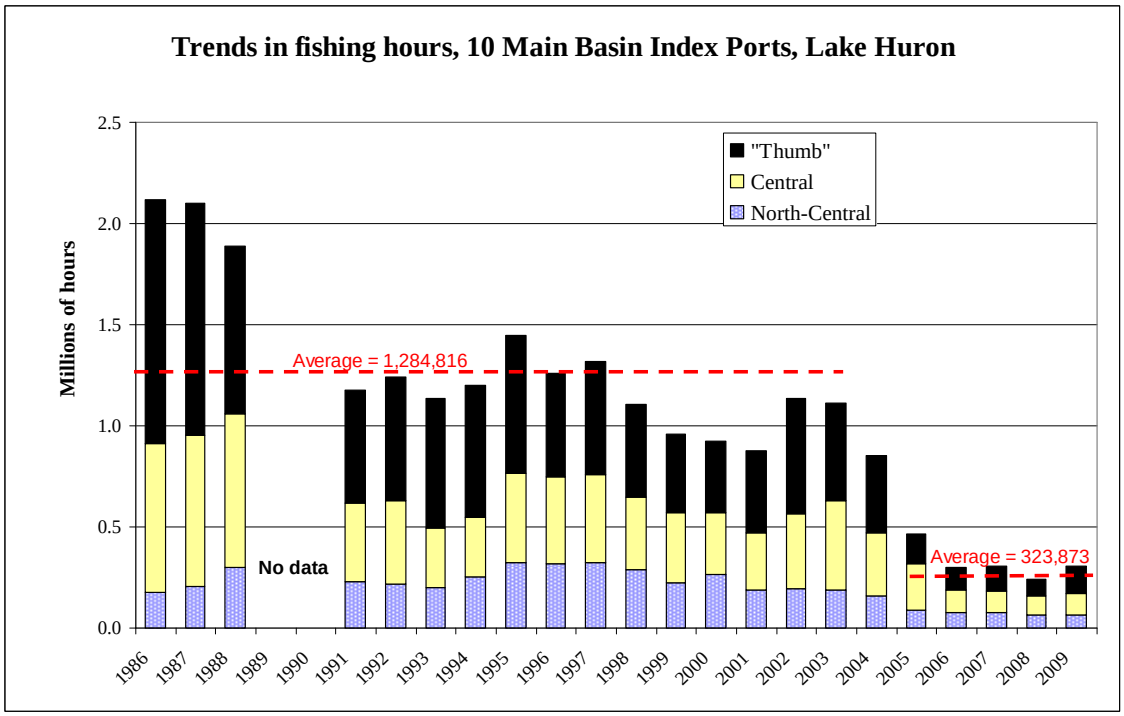


Figure 2. Trends in hours of fishing at the 10 index ports, Main Basin of Lake Huron. Fishing pressure declined by 75% after 2004.

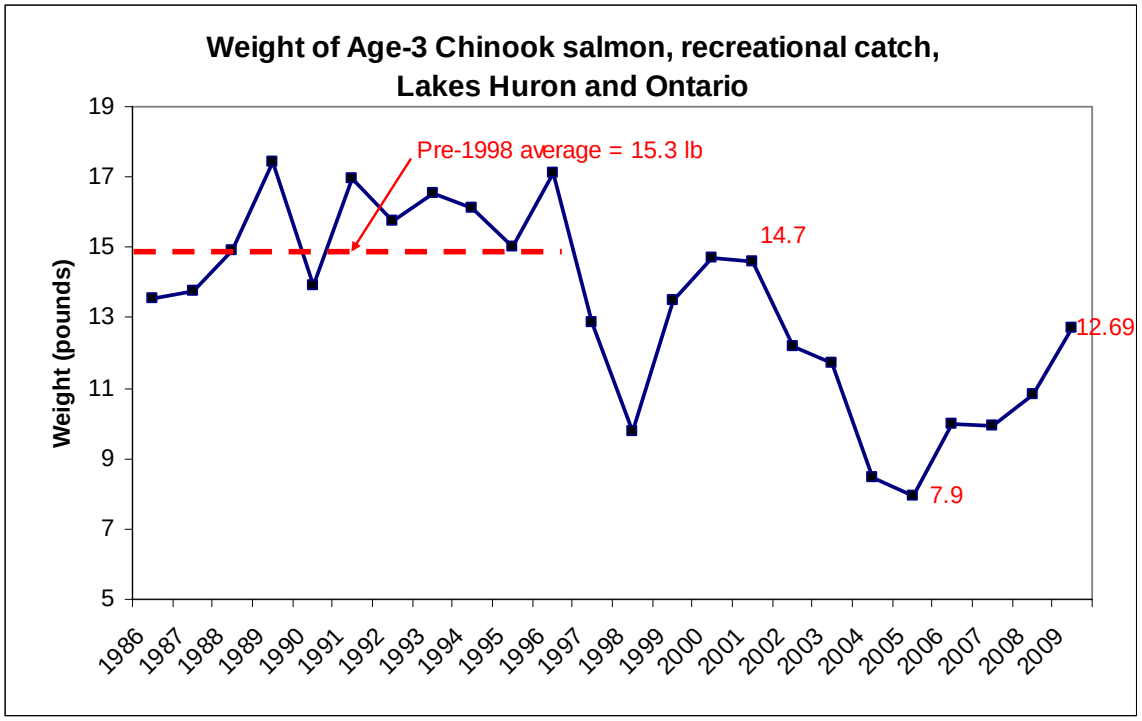


Figure 3. Weight of three-year-old Chinook salmon declined to a record low of only 7.9 pounds in 2005. Average weight recovered to near the pre-1998 average by 2009.

Figure 4. Chinook salmon suffering malnutrition, fall 2004.

4. **Lake trout** catch rates (Figure 5) soared to the highest ever seen in Lake Huron in 2004 and 2005 then declined somewhat thereafter. In 2004 lake trout replaced Chinook salmon as the lead salmonid harvested by anglers in Michigan's waters of Lake Huron. The rise in the lake trout fishery is attributed to their rise in numbers following the successful treatment of sea lampreys in the St. Marys River, more restrictive harvest controls provided by the 2000 Consent Decree and higher vulnerability to angling. By increased vulnerability we mean that lake trout are easier to catch when they are hungry; they spend more time feeding and are thus more likely to hit a lure. And they are hungry now that alewives are almost gone. Although lake trout growth rates have declined with the alewife collapse, they remain healthy and are not showing signs of emaciation. Unlike Chinook salmon, they appear to be adapting to new prey sources. Since 2003 lake trout have been turning to round gobies for food. This means they are spending

more time feeding near the bottom. Anglers presenting their lures near the bottom are being rewarded with excellent catches of lake trout.

The lake trout

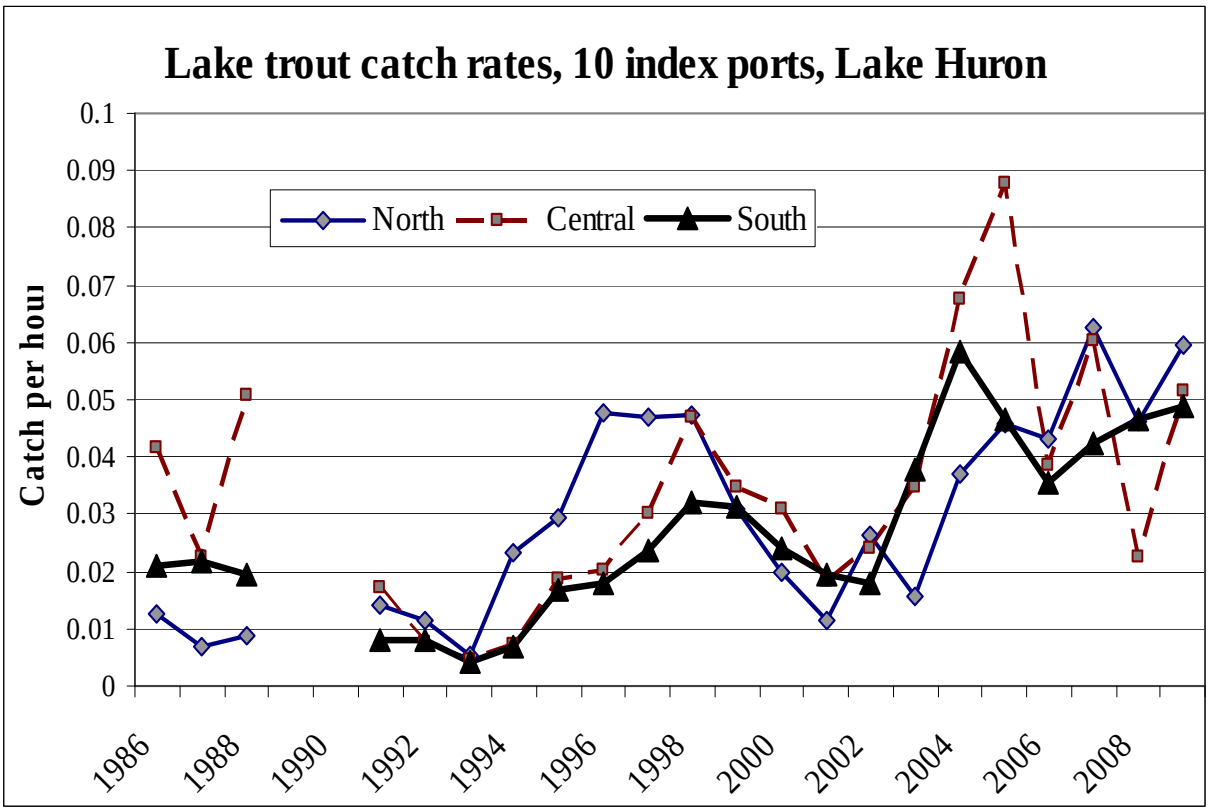


Figure 5. Lake trout catch rates rose sharply from 2003-2005. Lake trout have switched from a diet of mostly alewives to one of round gobies and smelt.

5. **Walleye, even more than lake trout,** capitalized upon the new foodweb and by 2007 were leading the recreational harvest of all sport fish, even lake trout. We

have now learned that walleye cannot reproduce when alewives are abundant. Evidently, adult alewives had been eating nearly all the walleye fry. The alewife collapse of 2003-04, therefore, led to the most pronounced walleye reproduction ever measured in Saginaw Bay. As the huge 2003 and 2004 year classes grew big enough to catch, angler harvest reached record proportions (Figure 6). In 2009, nearly 1,000,000 pounds of walleyes were harvested by recreational fishers on the Michigan side of Lake Huron. The heart of Lake Huron's walleye fishery is Saginaw Bay, but excellent numbers of walleyes are also available in Thunder Bay and near the mouth of the AuSable River. Walleyes are now more frequently being caught even off Main Basin ports that have traditionally been considered deep-water trout and salmon ports.

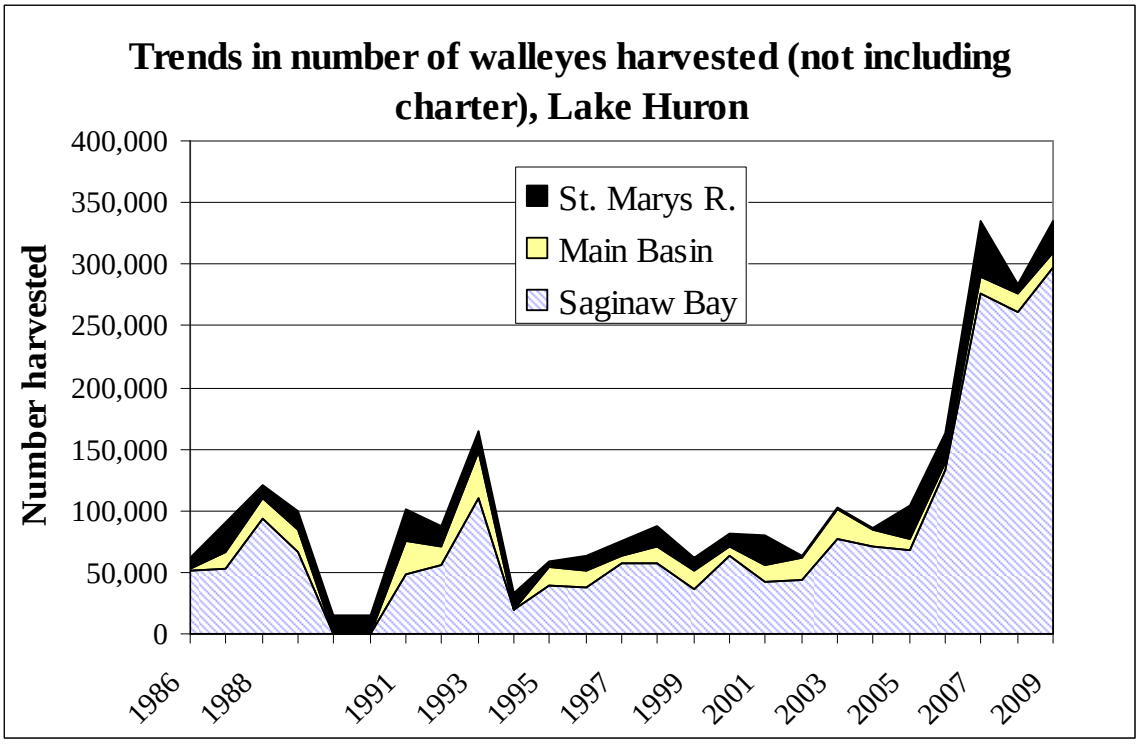


Figure 6. Trends in recreational walleye harvest from Michigan waters of Lake Huron, including Saginaw Bay.

6. **Whitefish** are Lake Huron's lead commercial fish. Whitefish growth has declined and they have become thinner, which has eroded their marketability and price per pound. The decline in whitefish growth and condition is almost

certainly caused by the disappearance of Diporeia, which for eons had been the preferred prey of lake whitefish. Whitefish are now eating mostly quagga mussels, but these mussels are not nearly as nutritious as Diporeia. Some whitefish have switched to eating round gobies, which has improved their growth and condition somewhat and, more importantly to sport fishers, renders them more likely to take minnows and lures.

Commercial fishermen landing whitefish in Alpena in fall 2001.

7. **Native species** have begun reproducing at some of the highest rates measured since at least 1970. The recent rise in native fish reproduction is thought to be largely due to the alewife collapse. There are two theories of how alewives suppress native species: 1) trout and salmon that eat almost exclusively alewives suffer deficiencies of thiamine (the "alewife's revenge") that can be lethal to the predator fish and /or cause the predators to become infertile, and 2) adult alewives prey on, and compete with, the young of other species. Recovery of native predators such as **lake trout and walleyes** would act to maintain predation pressure on the beleaguered alewife population, which could in turn ensure future reproduction of native species.

Walleye reproduction in Saginaw Bay reached record levels in 2003, the year alewives collapsed. Two more huge year classes were produced in 2004 and 2005. More large year classes followed. As a direct result of this rise in reproduction, angler catch rates soared in 2006 to record levels (See Saginaw Bay studies on this web site) and have remained high ever since.

Lake trout reproduction appears to be rising. Approximately 50% of younger (less than 8 years old) lake trout in some samples taken in spring of 2010 were wild.

Yellow perch have been one of Lake Huron's most sought after game fish. Unfortunately, perch numbers in Lake Huron declined to record lows after 2005. As with walleyes and lake trout, yellow perch reproduction rose when alewives collapsed, but the young perch are being heavily preyed upon by Lake Huron's predators, both fish and birds. Thus, few perch now survive to a harvestable size.

The exception has been the perch fishery of the Les Cheneaux Islands. An interagency collaborative project to control cormorant numbers there has reduced predation on yellow perch by cormorants and led to a recovery of the perch fishery. The Les Cheneaux Island's northern pike and smallmouth bass fisheries have also recovered nicely.

Emerald shiners, another native fish, was once an important bait fish in Lake Huron. Emerald shiners staged a major recovery in 2005 and 2006, then became relatively scarce for a few years. In 2009, they became prevalent in the "Thumb" and Saginaw Bay areas of Lake Huron.

The emerald shiner

Shiners schooled in spring 2007

Emerald shiners live near the beach and in surface waters where summer temperatures are quite warm. We do not know yet how important emerald shiners will prove to be for cold water predators like trout and salmon. But if walleyes turn to shiners for food, this might provide the opportunity for many perch, that otherwise might have been eaten by walleyes, to survive to harvestable size.

VHS, the latest invasive threat.

Viral hemorrhagic septicemia (VHS), a virus native to Europe, was found in Chinook salmon, walleyes, and whitefish in Lake Huron in 2006. Like invasive mussels and gobies, the disease almost certainly entered the Great Lakes with ballast water discharges from salt-water-navigating ships. This disease has produced serious losses of fish, including yellow perch and walleyes, in Lake Erie. Trout are especially susceptible to VHS in Europe. VHS presents a new threat to Lake Huron's trout, salmon, and whitefish fisheries and could deal a setback to perch and walleye recoveries. For more about VHS please click on the following link:

http://www.michigan.gov/dnr/0,1607,7-153-10364_10950_46202---,00.html

What's it all mean?

Clearly Lake Huron is experiencing the full force of an invasive species storm, (see the 1-hour film documentary "*Lake Invaders, the Fight for Lake Huron*") precipitated mostly by stow-away creatures in the ballast water of salt-water freighters.

Midwater (pelagic) food supplies declined sharply after exotic mussel colonization of Lake Huron. Nutrients that once fed the pelagic fish community are now locked in beds of zebra and quagga mussels. Plankton and 'shrimp' (Diporeia) declined, contributing to the collapse of alewives, the principal food of Chinook salmon. Chinook salmon feed almost exclusively in the pelagic zone rather than the bottom; thus Chinook salmon are especially vulnerable to the effects of mussel colonization. Lake trout and walleyes, on the other hand, are more opportunistic feeders and appear to be adapting to the new food web. The invasive round goby frequently appears in the diets of walleyes and lake trout, but seldom in Chinook salmon. Lake whitefish once fed heavily on Diporeia. There is

much uncertainty regarding whether Diporeia will recover and how lake whitefish will fare in the absence of Diporeia. For now, whitefish are eating the much less nutritious mussels.

Rising reproduction rates of walleyes, yellow perch, and perhaps lake trout may mean that Lake Huron will become less dependant on hatchery supplementation than in the past. A less hatchery-dependent system will be significantly less costly to manage but will be more likely to produce "surprises". The lake's users will need to adapt to what the lake "chooses" to offer (and what the salt-water freighters bring in), rather than to what the DNRE can stock from its hatcheries. Agencies will be less successful than in the past in molding the lake to their wishes. For example, the current depressed state of Lake Huron's open-water food supply means that no amount of stocking or other management is likely to bring back the kind of Chinook fishing Lake Huron was known for.

For more information:

A through description of the ecosystem disruptions caused by invasive species is in the Lake Huron Binational Partnership 2008-2010 Action Plan at the following web address:

http://epa.gov/greatlakes/lamp/lh_2008/index.html

This web address takes you to the index of the report. Most fisheries and other aquatic foodweb issues are addressed in Chapter 4 of that report.

You may also be interested in the one-hour documentary "*Lake Invaders, the Fight for Lake Huron*", which describes the efforts of the Alpena Fishery Research Station to investigate the effects of invasive species on Lake Huron and the economies and lives of people living on the shores of Lake Huron.