Lake Superior

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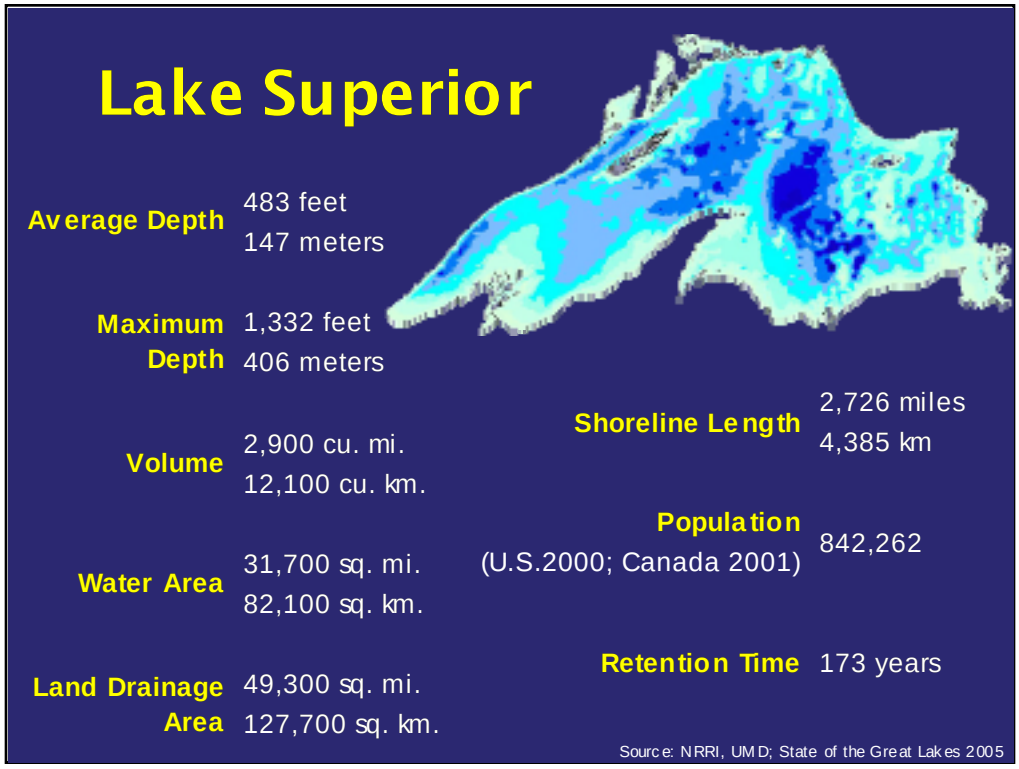
Good Morning! Today, I will be presenting two different topics: a short summary of the overall state of the Lake Superior ecosystem and a presentation on the status of Aquatic and Terrestrial Invasive Species across all the Great Lakes.

Incidentally, this picture, entitled "Glowing Rocks", was taken by GLNPO's Brenda Jones at Lake Superior's Picture Rocks National Lakeshore. It won first place in the 2008 "Great Lakes Forever" photo contest.

The overall theme of today's presentation is the importance of **Protection** of the Lake Superior ecosystem.



Lake Superior is the largest freshwater lake in the world by surface area, and the deepest of all the Great Lakes.

Since the theme of this conference is the nearshore, we wanted to point out that Lake Superior's nearshore is different from that of the other Great Lakes. Typically, nearshore impacts can be detected down to 100 meters or more.

The Lake Superior ecosystem is in generally good condition:

Bald eagle, gray wolf and peregrine falcon populations are recovering;

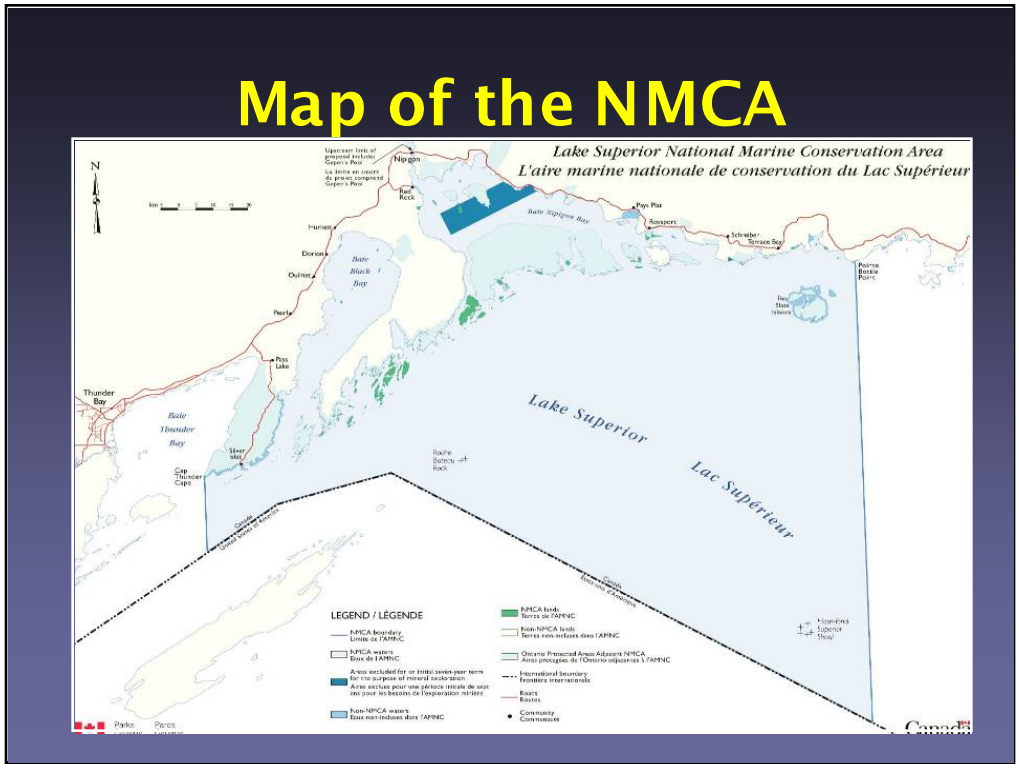
Fisheries are in good to excellent condition;

Lower food web is robust and stable;

Forest cover is increasing;

Contaminant levels are declining or remaining constant; and

There have been important habitat and land acquisitions, including (CLICK) …



…the Lake Superior National Marine Conservation Area in Canada.

In October 2007, the government of Canada announced the creation of their newest National Marine Conservation Area -- 10,000 square Kilometers on Lake Superior, representing the largest freshwater protected area in the world. Dumping, mining, oil and gas exploration and extraction are prohibited within park boundaries.

Lake Superior Ecosystem Faces Challenges

- Non-native species
- Shoreline development and hardening
- Habitat loss
- Aquatics species threatened
- Land use change
- Critical pollutants
- Substances of emerging concern
- Mining
- Climate change effects
- Protection

Although Lake Superior is the most "pristine" of the Great Lakes, it still faces challenges:

Non-native species;

Shoreline development and hardening;

Habitat loss;

Decline in some aquatic species, primarily as a result of habitat loss and shoreline development;

Land use change;

Critical pollutants and substances of emerging concern;

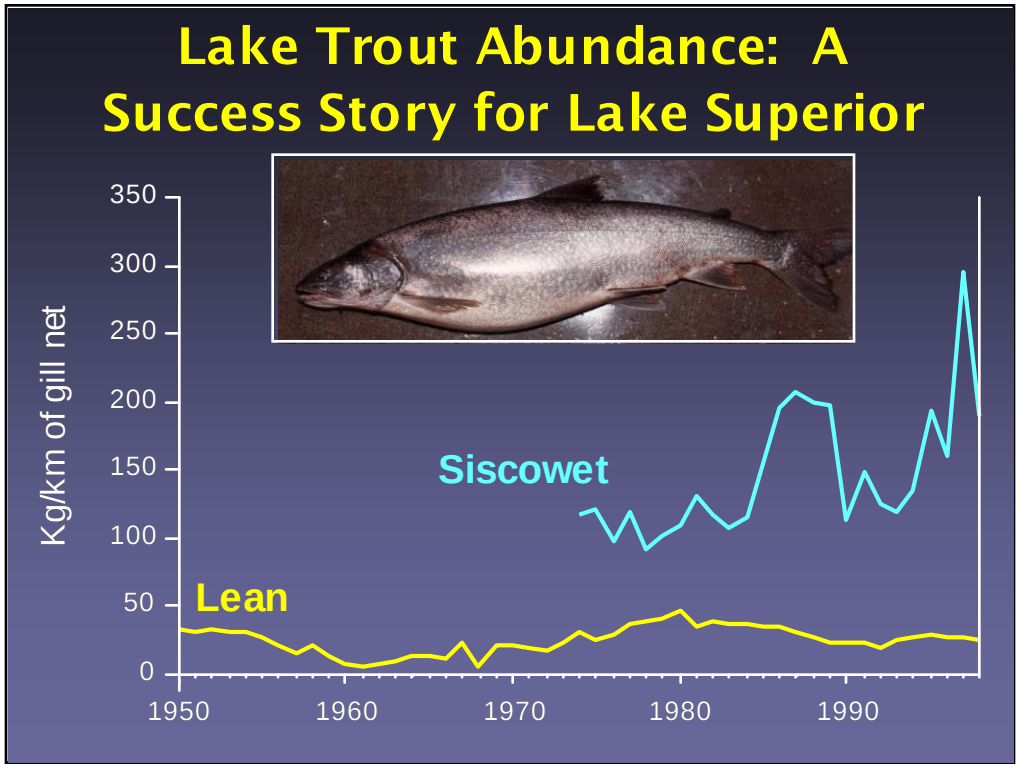
Mining;

Climate change effects, including lower water levels and higher water temperatures; and the most important challenge; and

Protection of its relatively unspoiled ecosystem.

I am now going to talk briefly about the status of the ecosystem components, starting with the state of the fisheries, another Lake Superior success story.

Lake Superior fisheries are in good to excellent condition. Whitefish and cisco are thriving and rehabilitation efforts are in progress for species of concern like lake sturgeon, walleye, coaster brook trout and short jaw cisco.



This slide represents one of the greatest success stories of Lake Superior – both lean and siscowet lake trout are near historic levels!

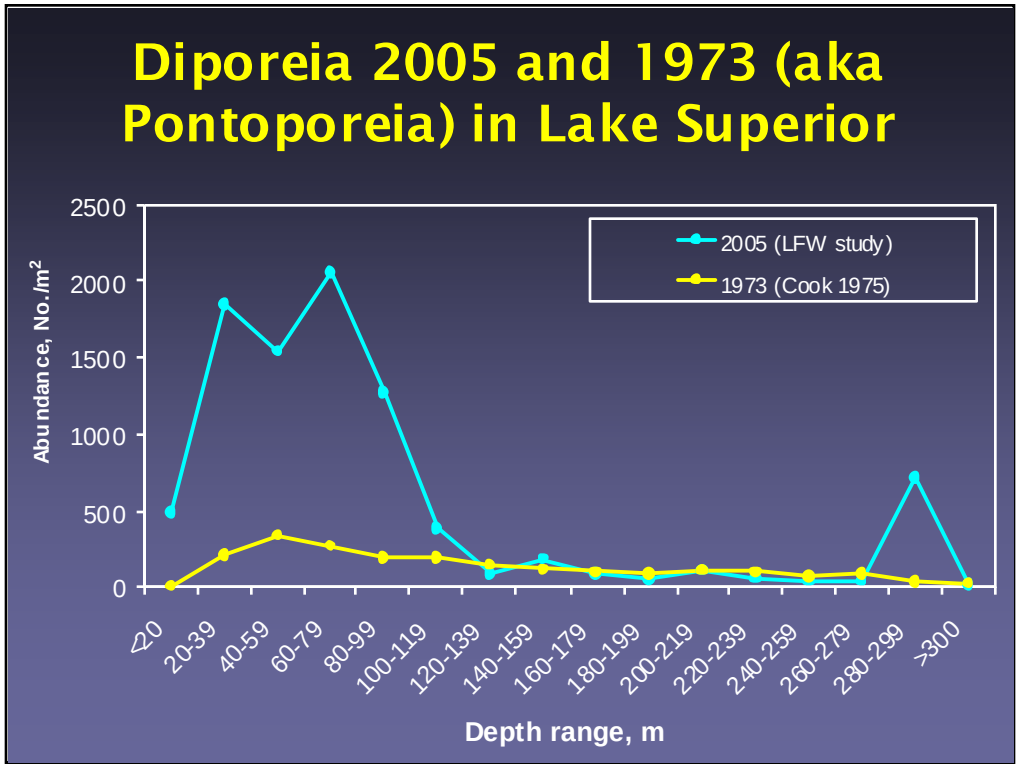
There are three main points about lake trout: 1) All forms of trout are very abundant; 2) they are naturally reproducing; and 3) although the siscowet shows high levels of toxic contaminants, this has not interfered with reproduction.

And, although this slide does not show it, lean trout have rebounded to historical levels, primarily because of government interventions such as stocking and regulations.

There are more naturally reproducing lake trout in Lake Superior than there are in all the other Great Lakes combined. These trout are reproducing on their own with very little management needed.

Lake Superior Lower Food Web

I am now going to turn briefly to the LS lower food web, including the status of diporeia, pictured here.



These next two slides are from Jack Kelly and his group at the EPA Duluth Lab, showing the analyses and results from the 2005- 2006 Lake Superior Coordinated Monitoring year.

This slides show two things: the nearshore location of diporeia and the abundance comparison from 2005 and 1973. The blue lines and solid dots represent 2005, the yellow lines and solid dots, 1973.

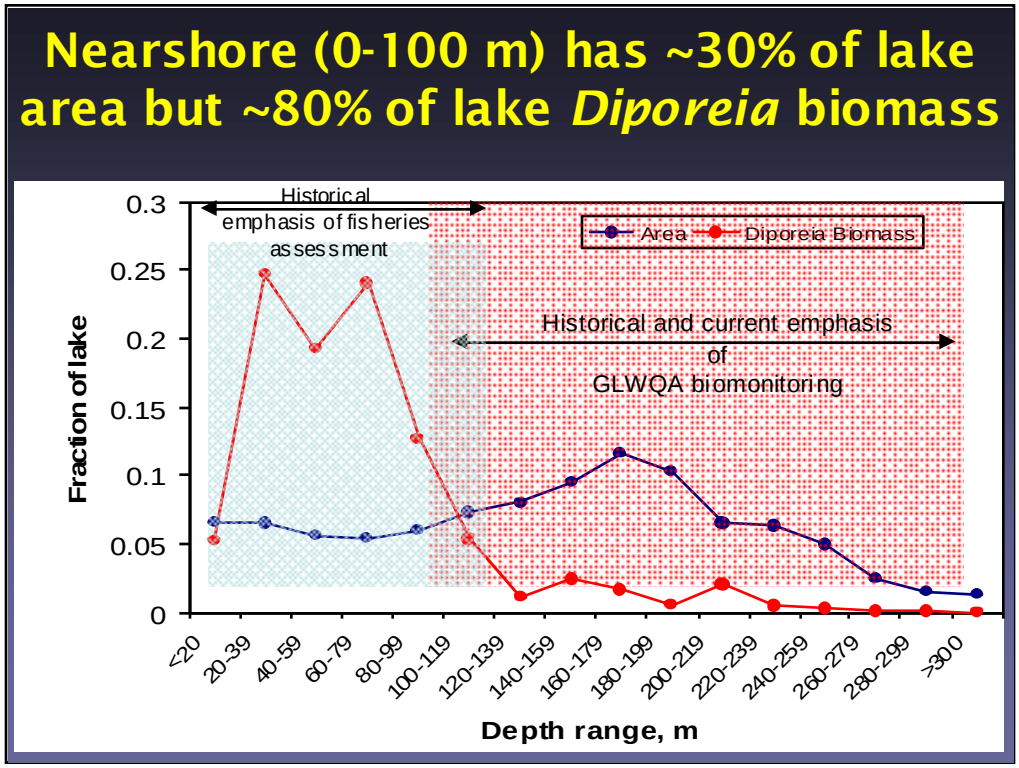
Notice the huge increase in the nearshore abundance, up to about 100 M in depth. Also notice that the current nearshore diporiea population is very robust, compared to the 1970's.

In 1973, there were about 10 trillion diporeia in Lake Superior. In 2005-6, estimated lakewide diporeia numbers were about 40 trillion give or take 1-2 trillion -- an increase of about 30 trillion!

These levels are significantly above the GLWQA objectives based on 1973 data.

This represents a terrific good news story for Lake Superior – and emphasizes why protection is so important for Lake Superior. Lake Superior is the only great lake with such a robust population -- dipoeria have all but disappeared in many areas of the other Great Lakes.

Incidentally, current biomass estimates are about 66,000 metric tons of wet weight, which could support about 7000 metric tons of fish. 66,000 metric tons would be about the weight of 1 million people....it's a big lake!



This first slide shows that diporeia prefer the nearshore in Lake Superior – the nearshore has only30% of the lake area but 80% of the diporeia biomass.

(Click) Current monitoring has been an offshore open water program and does not capture this inshore biomass. Off-shore monitoring very poorly estimates the lakewide biomass of Diporeia –and would almost completely miss the diporeia story in Lake Superior.

(Click) To capture the complete picture of fisheries and biomonitoring in Lake Superior, the Lake Superior Binational Program is looking into an integrated nearshore and offshore fisheries/biomass assessment.

Contaminant Trends in Lake Superior

Now, I will talk about Lake Superior contaminant trends.

In case you wondered, this picture represents some of the burn barrels collected through Minnesota Pollution Control Agency's "barrel for a barrel" program, where burn barrels could be swapped for rain barrels. Residents were asked to sign a "no burn" pledge and to bring in their old burn barrels. This program has helped in the reduction of open trash burning, and consequently, dioxin releases to the Lake Superior basin.

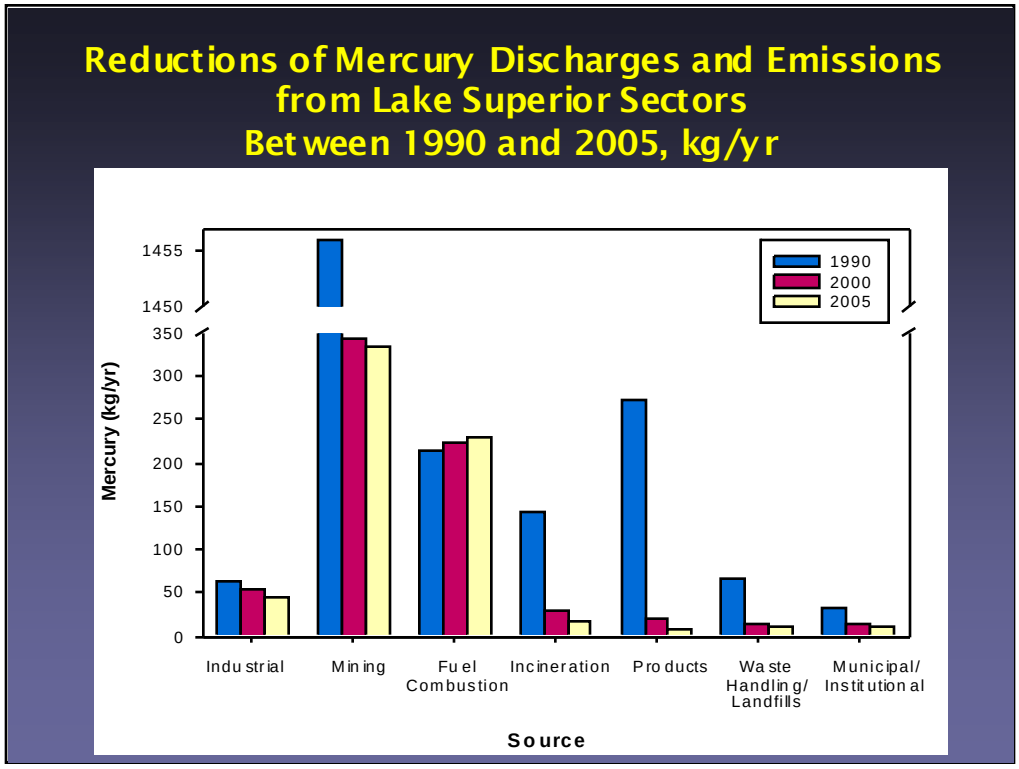
Other Lake Superior Great News stories include --

Dioxin releases have dropped 76-79% since 1990;

PCBs continue to be phased out;

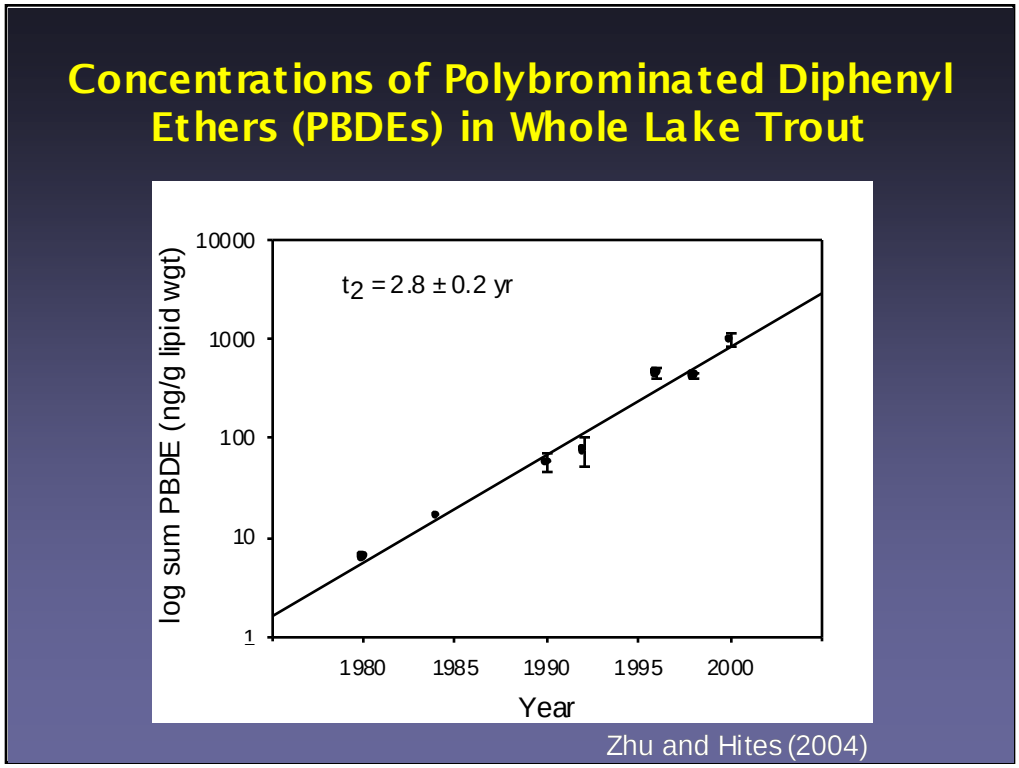
More than 28,000 lbs of waste pesticides associated with the zero discharge demonstration program have been collected since 1992;

And (Click)



Mercury releases have dropped 71% since 1990!!

This graph shows the reduction by sector in mercury releases to the Lake Superior basin between 1990 and 2005. Take a look at the decline in mercury in mining, incineration and products. However, we do expect a possible increase in mercury emissions from mining, as I will talk about shortly.



This slide shows that substances of emerging concern continue to pose a problem for Lake Superior.

Archived Lake Superior trout were analyzed for PBDEs (flame retardants) and showed an exponential increase over time with doubling every 2.5-3 years!!

Most recent concentrations are about 5 times greater than those measured in fish from Europe.

The Lake Superior LaMP has identified the importance of substances of emerging concern and has developed a "Management Strategy" to address these. The Strategy will focus on pollution prevention, identify potentially new Lake Superior critical pollutants, and report out on monitoring needs and the state of the science.

The mining industry is of primary concern in the Lake Superior basin – this is a Lake Superior-specific issue. We are increasingly concerned about the impact of mining on the Lake Superior ecosystem, especially with regard from a possible increase in mercury emissions and destruction of wetlands and habitat.

In our 2005 mercury inventory, mercury emissions from taconite mining, primarily in MN, represented 51% of the total mercury emissions to the Lake Superior basin.

Specifically, the taconite mining sector emitted 300 kg/yr of mercury in 2005.

The taconite and non-ferrous mining industries are experiencing an expansion, with numerous new mines being proposed -- and minerals exploration occurring -- basinwide.

Other ecosystem effects associated with mining development include acid mine drainage, wetland and habitat loss, regional air haze, impacts on coaster brook trout populations, mercury methylation stimulated by sulfate discharges, impact of hydrological change on wild rice, and loss of access to tribal treaty resources.

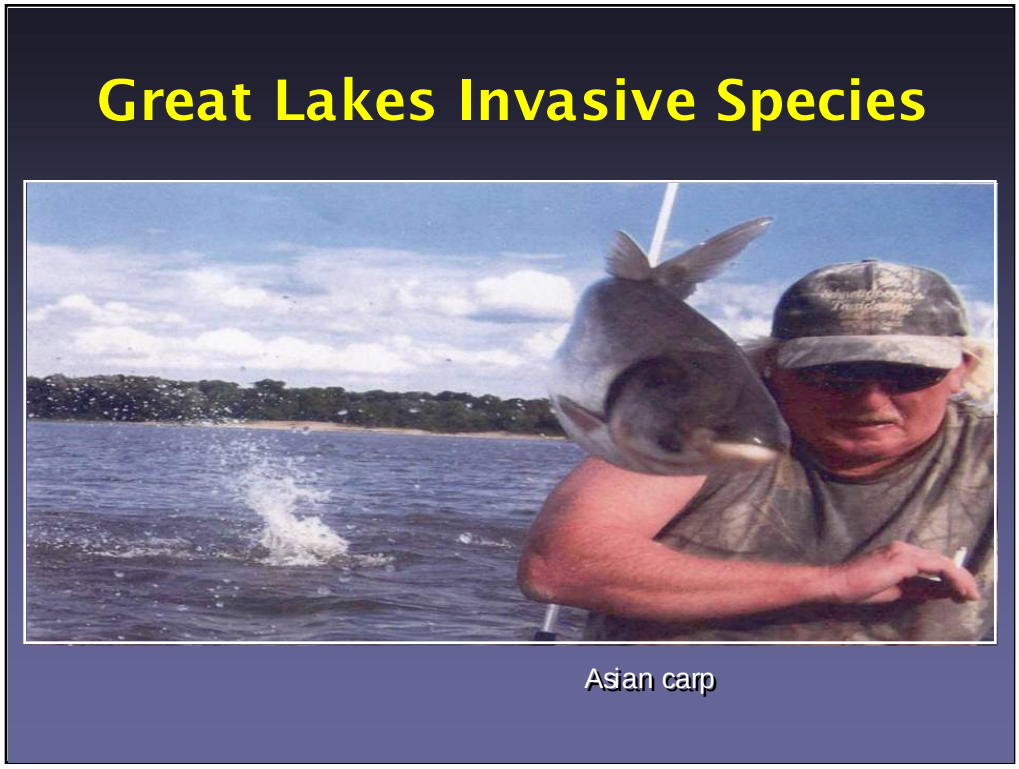
For example, the wetlands loss associated with one of the mines, PolyMet, is estimated at over 1000 acres, the single-largest loss ever considered by the St. Paul District of the Army Corps of Engineers.

The Lake Superior habitat and terrestrial wildlife populations are in generally good condition. Important habitat sites have been mapped – and some have been acquired – specifically, 60 acres of important spawning sites on the lower Npigon River, Ontario.

And, for the first time, the Lake Superior Work Group has developed "Ecosystem Goals" -- specific objectives -- quantifiable when possible – which are necessary to achieve and protect a diverse, healthy and sustainable Lake Superior ecosystem. These ecosystem goals include specific climate change actions that will help mitigate greenhouse gas emissions to the Lake Superior basin.

Herptile Monitoring in the Lake Superior Basin

One of the ecosystem goals is to "institute a long-term Lake Superior basin-wide program to monitor ecosystem health" including that of herptiles. In fact, a Lake Superior basinwide herptile monitoring project was just developed that will help with herptile habitat and restoration. Results should be applicable basinwide.



The rest of my presentation today will focus on invasive species – both terrestrial and aquatics. Much of the good work in other Great Lakes areas such as toxic reduction and habitat restoration, is being undermined by continued major impacts of invasives.

Since the 1800s, approximately 184 non native aquatics species of all types - including plants, fish, algae and mollusks - have become established in the Great Lakes.

Invasives have been identified as the greatest threat to the world's freshwater biodiversity of lakes -- and are the second leading cause of threatened and endangered species in the United States.

Today, one estimate is that annual costs may be on the order of 200 million!!

Incidentally, pictured above is an asian carp, a species now less than 30 miles from Lake Michigan —- and one that we really want to keep out of the Lakes. This is an aggressive species with a voracious appetite.

"Invasive species are everywhere. They damage our crops, our industries, the environment and public health. Scientists, academics, leaders of industry and land managers are realizing that invasive species are one of the most serious environmental threats of the 21st century."

- National Invasive Species Council (2001)

A invasive species is one:

that is not native, and

whose introduction causes, or is likely to cause, economic or environmental harm or harm to human health.

This slide shows some bad actors everyone knows well. Think about how much these and other invasive species have changed the Great Lakes. Invasive species have caused food web disruptions, predation problems, water intake and infrastructure fouling, and have cost billions of dollars just to control or repair damages.

Effects have been permanent and enormous.

Terrestrial Invasive Species

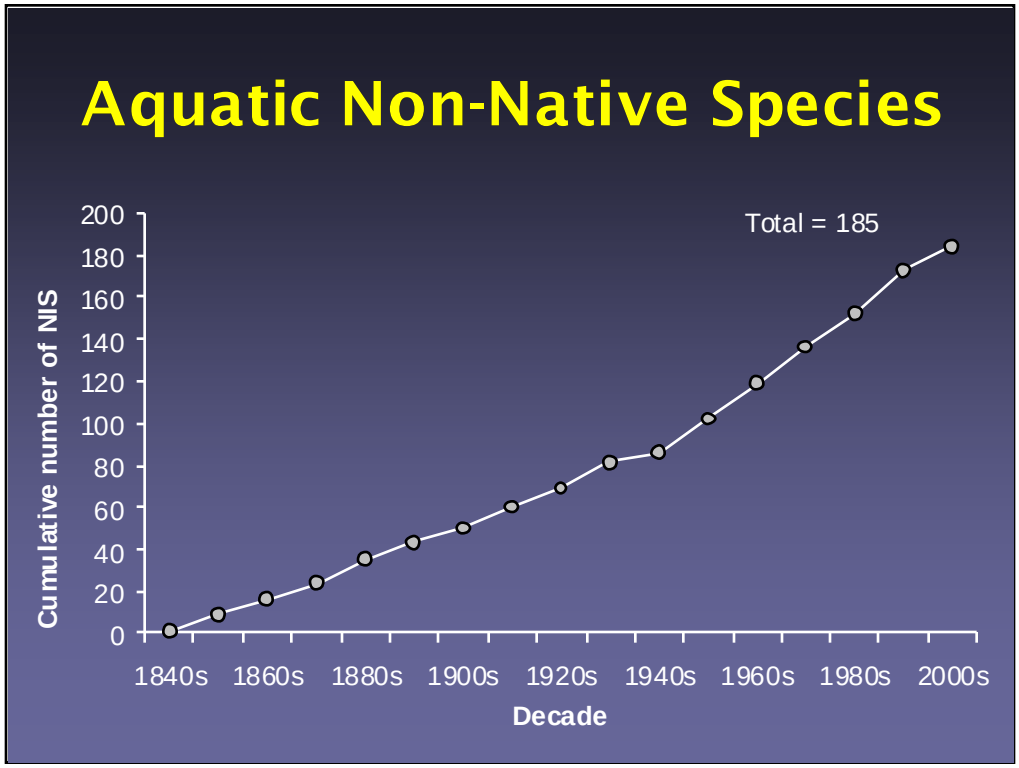
- Phragmites
- Purple Loosestrife
- Exotic buckthorns
- Asian longhorned beetle
- Emerald ash borer

Emerald ash borer

This slide lists some example of terrestrial invasive species. One of the most potentially devastating invasives is the Emerald **Ash Borer**. I had hoped to be able to say that the borer is not yet found in the Lake Superior basin, but in fact infestations were just discovered in Michigan's Keweenaw Peninsula and new quarantines have been established for several counties in the Upper Peninsula of Michigan. All ash trees across the whole Great Lakes basin are at risk of dying from the borer.

One innovative program to address terrestrial invasives is the "Invasive Free Zone" project at the Whittlesely Creek National Wildlife Refuge in Ashland, WI.

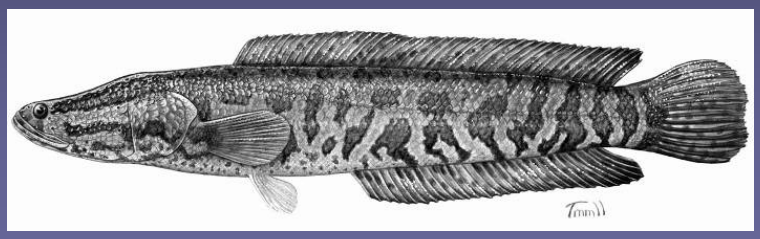
This project seeks to eradicate terrestrial invasive plants on a landscape scale, across federal and private lands. The project identifies, maps and then eradicates invasives. Based on this pilot project, at least 10 additional Invasive Free Zones have been started throughout the eastern U.S.



Despite all the known negative impacts and even with various control programs, new species continue to arrive in the Great Lakes. This chart shows cumulative non-native species introductions and if I may interject a value judgment about the data, it does not look good. We simply have to do better. I hope that in presentations at future SOLECs, this graph will show a leveling off. It will never show a decline because once introduced, eradication of an invasive species is all but impossible, except in very small areas.

Imminent Invasives

Killer Shrimp



Snakehead

Unfortunately, there are a number of scary-looking and sounding invasives that are poised to enter the Great Lakes – these include the snakehead, monkey goby, and killer shrimp. The snakehead, for example, is very predatory, can breathe air and can travel short distances over land. Another emerging invasive, and one that has unfortunately been detected in the Great Lakes basin is... (click)

Emerging Invasive: Didymo

Invasive freshwater alga *Didymosphenia geminata*

… the Didymo, courtesy of the Faroe Islands, north of Scotland. Didymo is an invasive freshwater algae that has an extraordinary capacity to cover stream surfaces with an inordinate amount of stalk material. It can smother streambeds, thereby depriving freshwater fish, plants and invertebrates of habitat. It has the potential to dramatically impact the food web.

I will now talk briefly about the status of invasives specific to each Great Lake, starting with Lake Michigan. As you will see, many of the invasives are common across all the lakes.

The Lake Michigan ecosystem has been dramatically altered by aquatic invasive species – especially by quagga and zebra mussels. The native diporeia are declining dramatically -- by 95% between 1995 and 2005, most likely as a result of the quagga mussels. Zebra mussels are declining but being replaced by the more adaptable quaqqa mussels in higher numbers than ever seen by zebra mussels at their height.

The increase in quagga mussels has been linked to the dramatic increase in the algae, cladophara, the spread of type E Botulism, and massive bird die-offs along the shores of Lake Michigan. The Lake Michigan speaker, Ken Hyde, will elaborate on botulism and bird die offs in his talk.

Another invasive species, one which is invisible to us, is the Viral Hemmoraghic septicema virus, which has caused significant fish mortality events in Lake Michigan.

Although Asian carp have not yet been seen in Lake Michigan, they remain a threat and are within 30 miles of the lake. They are held back by a series of locks and dams which are not particularly good barriers. An electric barrier in the Chicago Sanitary and Ship Canal is a barrier of last resort to protect the Great Lakes.

A new species of AIS, the bloody red shrimp or Hemimysis, was reported in Lake Michigan for first time in 2006, along with a report in Ontario. Phragmites, or common reed grass, is becoming a major problem in the Lake Michigan basin, rapidly spreading over large areas of the nearshore. The round goby continues to cause problems in Lake Michigan and appears to be increasing.

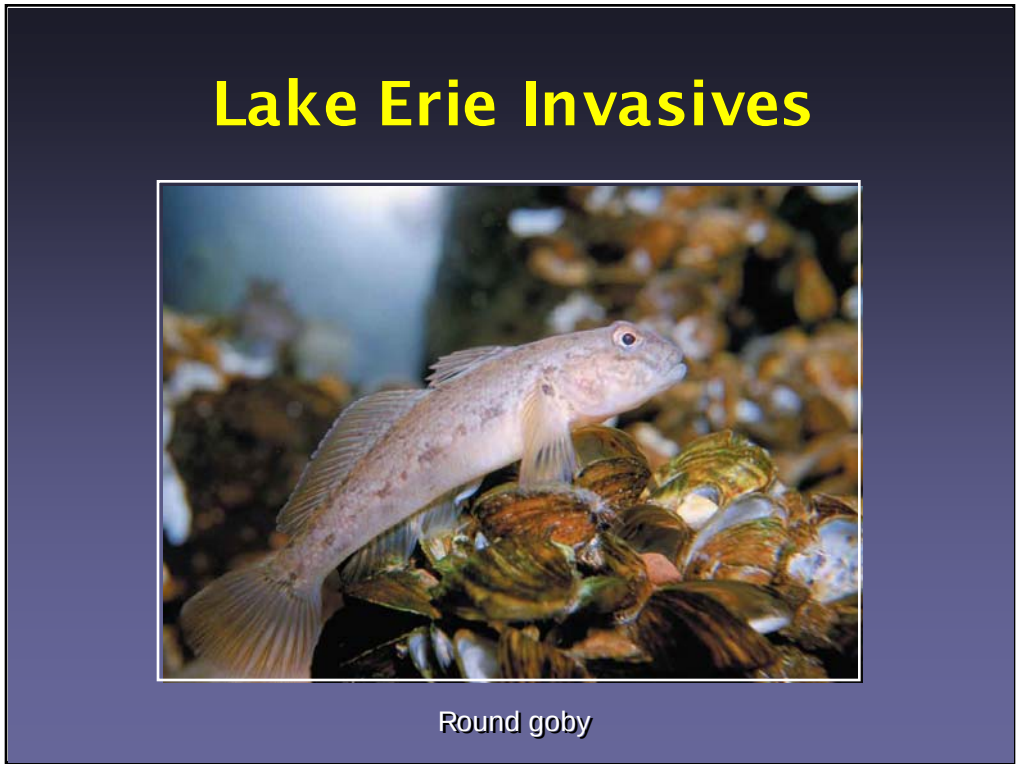
As with Lake Michigan, the effect of invasives on the Lake Huron ecosystem has been devastating – diporeia has all but disappeared, most likely due to competition for food with non native species, and/or the sequestering of nutrients by invasive mussels.

The same cycle of cladophora proliferation, increase in Type E botulism and bird die-offs that we saw in Lake Michigan have also occurred in the Lake Huron ecosystem.

Phragmites, as in Lake Michigan, is a huge problem, having taken over large areas of Saginaw Bay.

Sea lamprey continue to be a problem in Lake Huron – an adult can kill and consume up to 40 pounds of fish in 12-20 months. The St. Mary's river has become the major spawning area for lamprey in the Great Lakes. By the 1990's, the St. Mary's River was producing more lamprey than all other Great Lakes combined, thus hampering successful lake trout population rehabiliation.

VHS, a 3 letter word to fisheries managers, has caused large scale die-offs of some fish species in Lake Huron and has led to significant restrictions on anglers, boaters, and commercial interests.



Of the 184 invasive species in Great Lakes basin, 132 are in the Lake Erie basin. The relatively warm, shallow waters of Lake Erie have been hospitable to incredible population explosions of invasive and native species.

The Emerald ash borer has killed millions of ash trees in the western Lake Erie drainage basin.

Again, VHS is of concern, having led to massive fish dieoffs in the basin.

As with the other lakes, ecosystem effects of invasives include… (click)

Lake Erie Algae Aerial

…the massive algae blooms, spread of Type E botulism and bird die-offs.

The scale of the bloom is demonstrated by the power boat traveling up the center of the photo.

Similar profound effects of invasives are occurring in Lake Ontario -- Zebra and quagga mussels, spiny waterflea and fish-hook waterflea are causing food web disruptions;

Quagga mussels dominate the bottom of the lake to depths of up to 90 metres and are "muscling" out diporeia;

The decline of diporeia is so great that dipoeria may be at risk of completely disappearing from Lake Ontario;

The newest invader is the bloody red shrimp, native to the black and caspian seas, found in 2006. It competes with young fish and has been found in the diet of larger fish. VHS is also a problem.

Blue green algae blooms have occurred, likely due to quagga and zebra mussels.

Lake Superior represents the end of the route for shipping and many invasive species. Although the cold, oligotrophic water has protected the lake from many new species, Lake Superior could very well have its own special invasive species problem in the future. In fact, Lake Superior has the highest rate of non-native species to native species of all the Great Lakes.

In particular, the harbors and tributaries are vulnerable because they provide better habitat than the open waters.

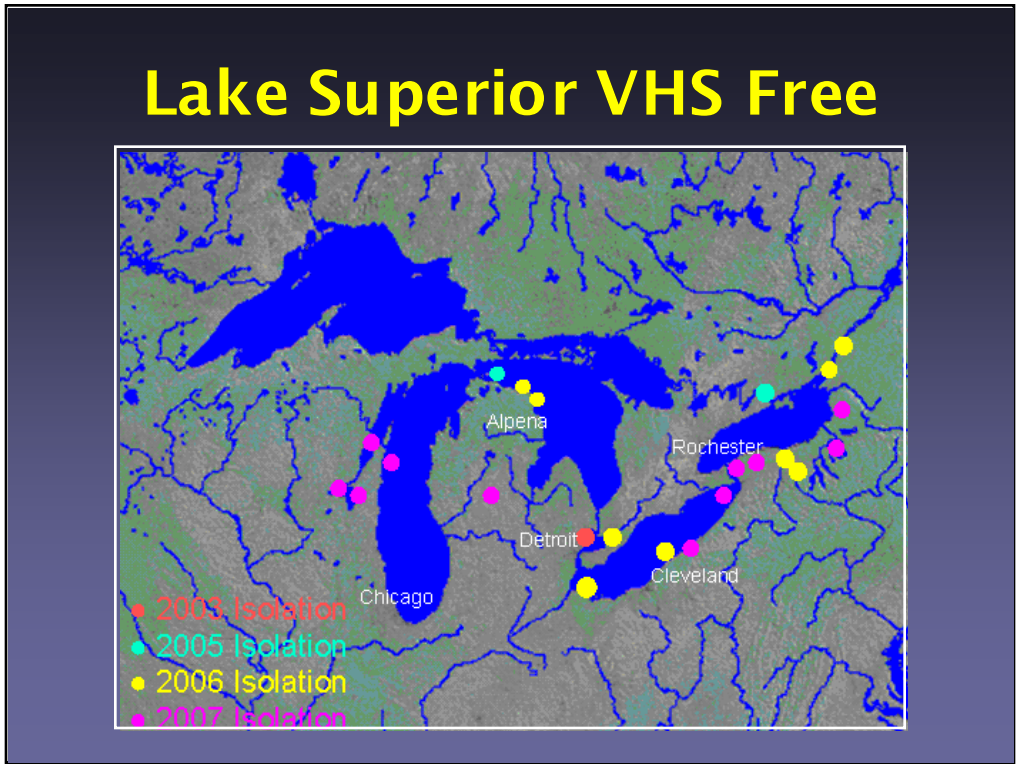
Climate change might make Lake Superior more hospitable to invasives as water temperatures continue to increase.

Lake Superior
Status of Introduced Species

Species	Range	Abundance
ruffe	Increasing	Stable
threespine stickleback	Increasing	Increasing
fourspine stickleback	Stable	Stable
white perch	Increasing	Increasing
round goby	Increasing	Stable
New Zealand mud snail	Increasing	Increasing
Chinese mitten crab	New	Low

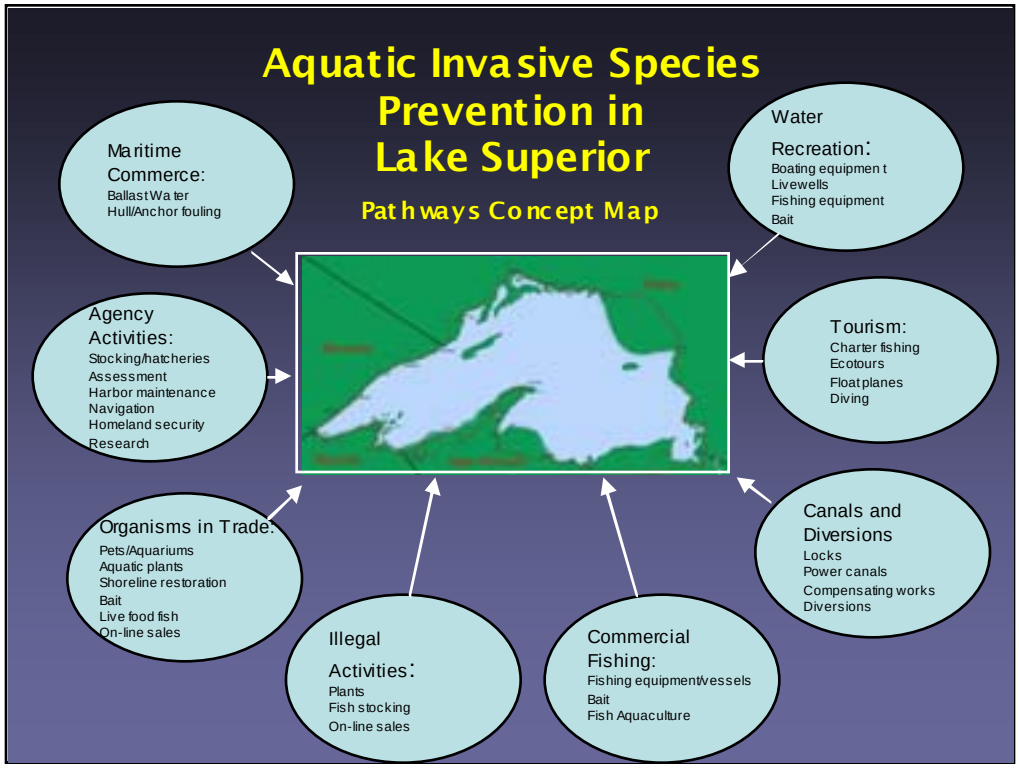
Here are some examples of aquatic invasives in Lake Superior, such as the New Zealand mud snail, which you can see here, compared to a dime. As you can see, many are increasing in range and abundance.

However, for now, the 32 non-native species in Lake Superior have been mostly manageable up to this point, though at a very high economic cost.



As you can see, Lake Superior is the only one of the Great Lakes that is still VHS free – and we'd like to keep it that way. To this end, the National Park Service has prohibited ballast water discharge within park boundaries to prevent the spread of VHS.

I will next describe some actions – and a pilot program – for preventing all new invasives species in Lake Superior.



In Lake Superior, we are developing a pilot invasive species complete prevention plan, looking at closing the pathways in all the vectors. This chart shows the vectors and pathways under consideration.

For example, the Maritime Commerce vector, new protections are in place or are under consideration for ballast water regulations. New Minnesota rules require a permit for ballast water discharges that will lead to treatment of ballast in ships in Minnesota waters. Michigan has a new permit in place for ocean-going ships conducting port operations in Michigan that includes a requirement for treatment of ballast water.

For each of the vectors, the pathways will be identified and recommended actions for stopping new introductions will be in the Prevention Plan. For those of you interested in this, a discussion of the Lake Superior Complete Prevention Plan will occur during the breakout this afternoon.

Thank you to the Lake Superior Work Group and other people who helped make this presentation possible. See you at the afternoon breakout session on the Lake Superior Complete Prevention Plan for non native species.