I am honored to be asked to give the report on the State of Lake Michigan. The report will emphasize various physical integrity aspects of the Lake and its watershed by drawing on the work of many people and agencies over the last several years. During the overview of the State of Lake Michigan, we want to touch on some major themes including the sustainable use of water, concerns about human health related to the Lake, and some relationships between invasive species and their effects on the Lake. Although our report is not entirely flattering, we want to emphasize the importance of understanding the many and varied factors that impact this globally significant natural resource.

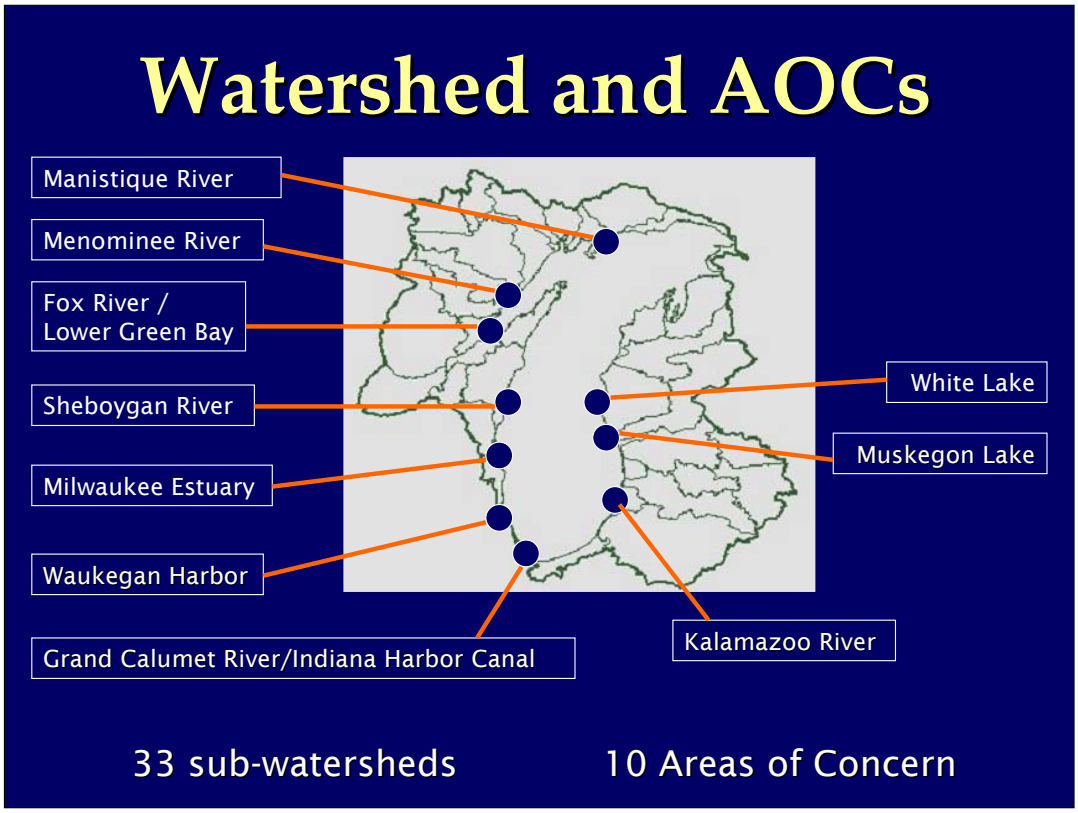
As determined by the Lake Michigan LaMP 2000 and confirmed by the 2002 and 2004 LaMPs, the status of Lake Michigan is mixed. For a lake the size and complexity of Lake Michigan, it is not surprising that there are some measures of improving conditions but others where they are not. For example, in the summer of 2004, Eagles were nesting on the Little Calumet River in Indiana for the first time since 1897. Also, while dam removals have proven to benefit restoring physical integrity and helped promote diversity of species at the same time that the levels of contaminants in fish remain in a range that triggers fish-consumption advisories. In addition, as some issues approach resolution, other new issues are emerging such as emerging contaminants and new invasive species. Since the overall status of the Lake involves the interactions of chemical, physical, and biological changes, it is necessary to try to understand the interactions of how improvements in one of these categories will affect the others.

The varied images shown in this slide illustrate some of the many ways we use Lake Michigan. A conference such as this one, gives us the opportunity to move toward the complex goal of sustainable use of the natural resources of the Lake Michigan watershed.

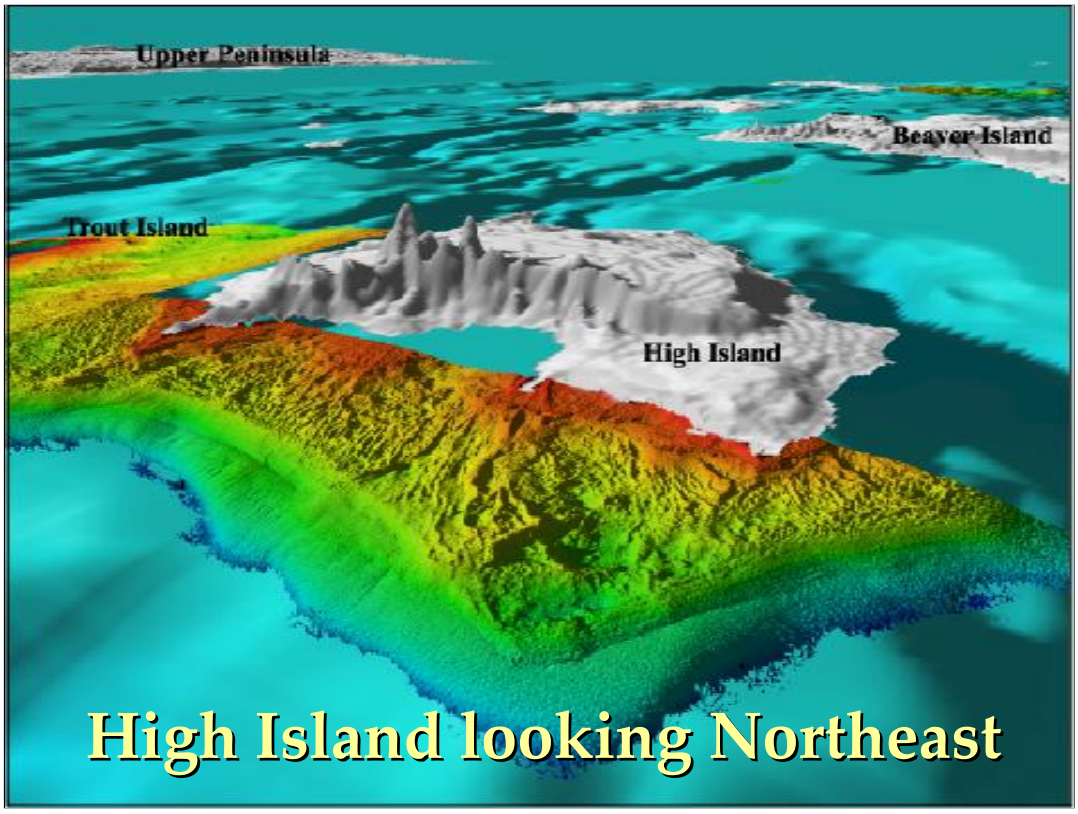
Outstanding natural resources

- 483 kilometers from northern forest to southern dune and swale
- Several rare features

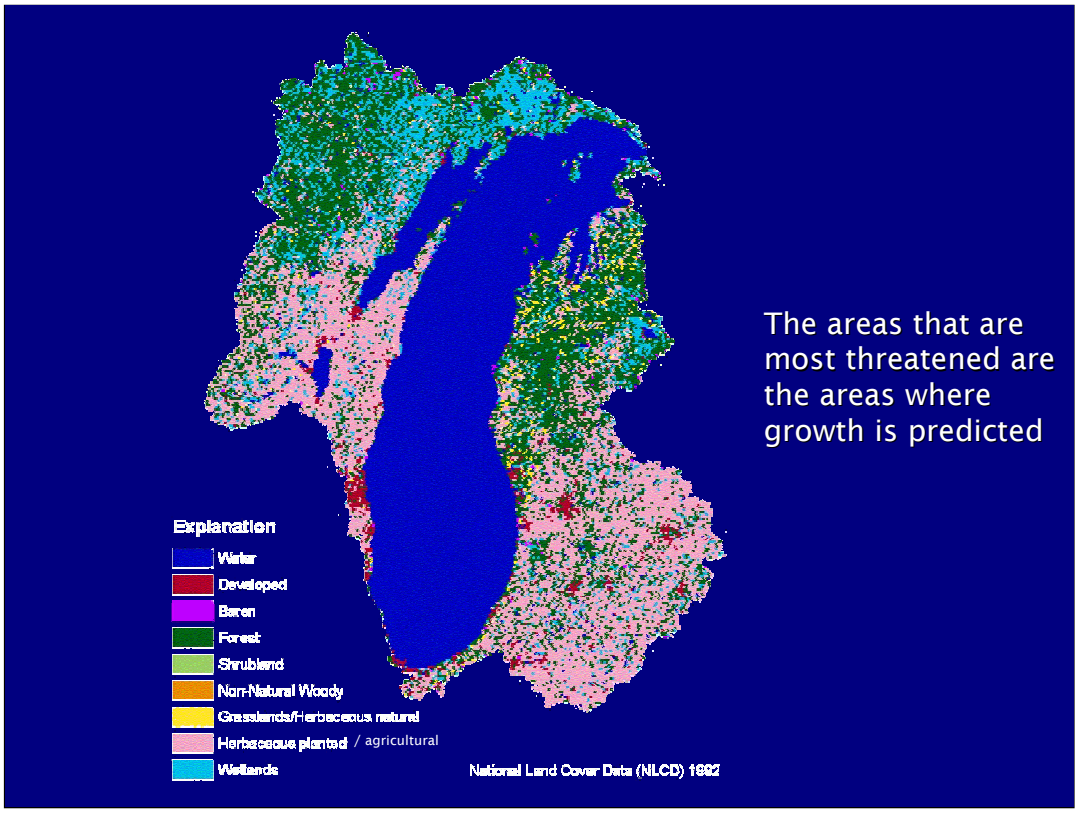
The Great Lakes are one of the most outstanding natural resources on the earth and constitute the largest concentration of unfrozen fresh surface water in the Western Hemisphere. Lake Michigan is the second largest of the Great Lakes by volume. Its watershed contains large forested areas as well as rare features such as alvars, prairies, and savannas. The ground-water resources of the Lake Michigan watershed are especially important to sustain streamflow during periods of low precipitation which helps contribute to ecosystem stability.



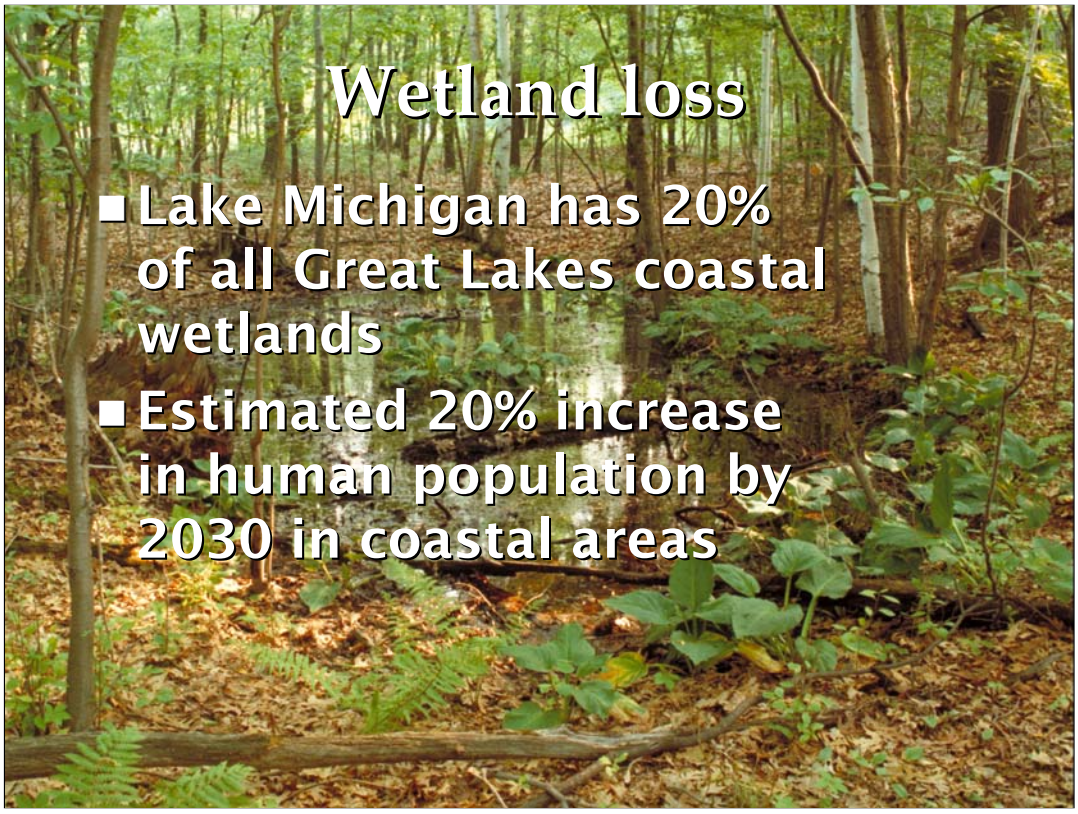
There are 33 sub-watersheds in the Lake Michigan drainage area with all but three sub-watersheds listed for impairments. Ten of the tributaries to Lake Michigan have harbors that are listed as Areas of Concern. All ten Areas of Concern have had some remedial work to address legacy sediment problems, but watershed issues like combined sewer overflows, dam removal, and habitat destruction and fragmentation are still ongoing.



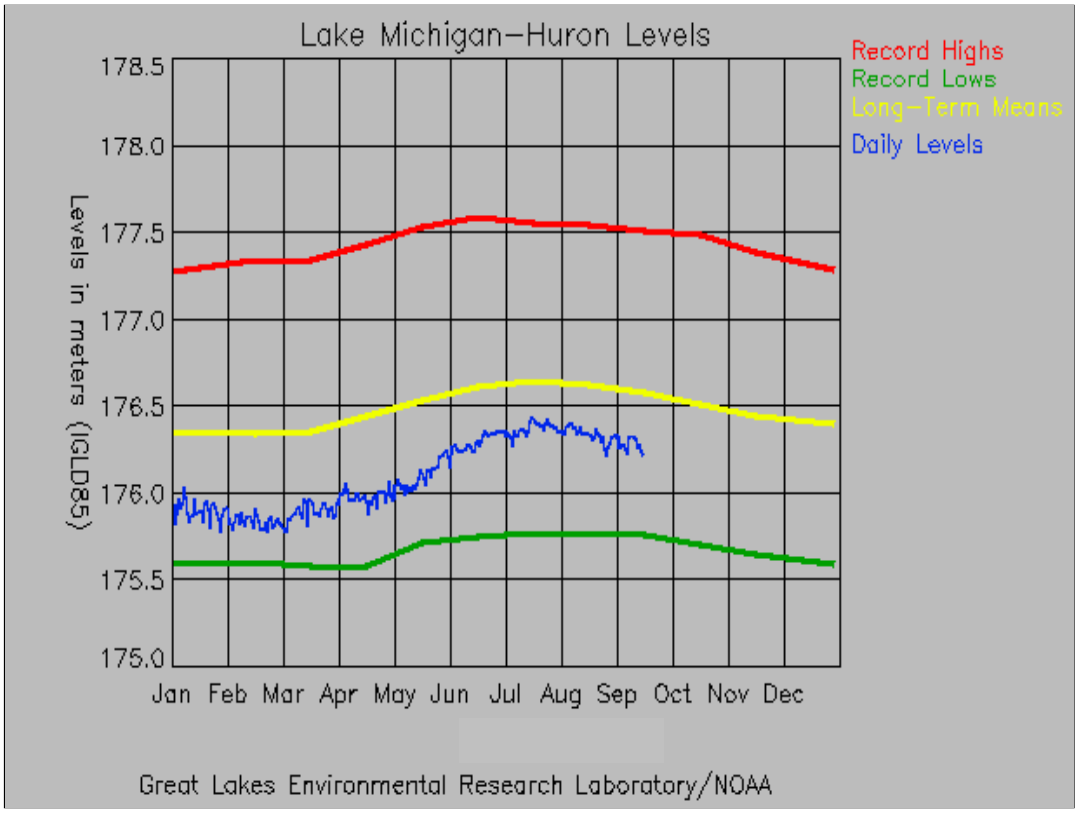
Lake Michigan contains important bays and underwater reefs that provide habitat and critical spawning areas for many aquatic species. Some of the most important spawning areas are reefs in Northern Lake Michigan that have shallow gravel/cobble substrate adjacent to deeper water. This slide shows an image of one of these reefs using underwater radar. The gray part of the image represents dry land and the colored part is below the water surface along High Island which is about 40 kilometers directly north of the Leelanau Peninsula. Understanding the physical nature of these reefs will assist fishery managers in restocking efforts in a key area that needs protection.



The Lake Michigan watershed has undergone many land-use changes from pre-settlement to present. This slide illustrates land-cover information from 1992 and the main developed areas in red, agricultural areas in tan, forested areas in green, and wetlands in light blue. Recent studies have demonstrated that development is occurring in some of the most ecologically sensitive areas of the watershed.



As can be seen from the previous slide, there are large amounts of coastal wetlands near Lake Michigan. It has been estimated that about 20 percent of all Great Lakes coastal wetlands are in the Lake Michigan basin and they are a key element to biodiversity and the aquatic food web associated with the Lake. Unfortunately, development on and near the coastal zone has been putting pressure on these coastal wetland systems. With human population predicted to increase by 20 percent by 2030 in the area, the pressure on these wetlands will likely increase.



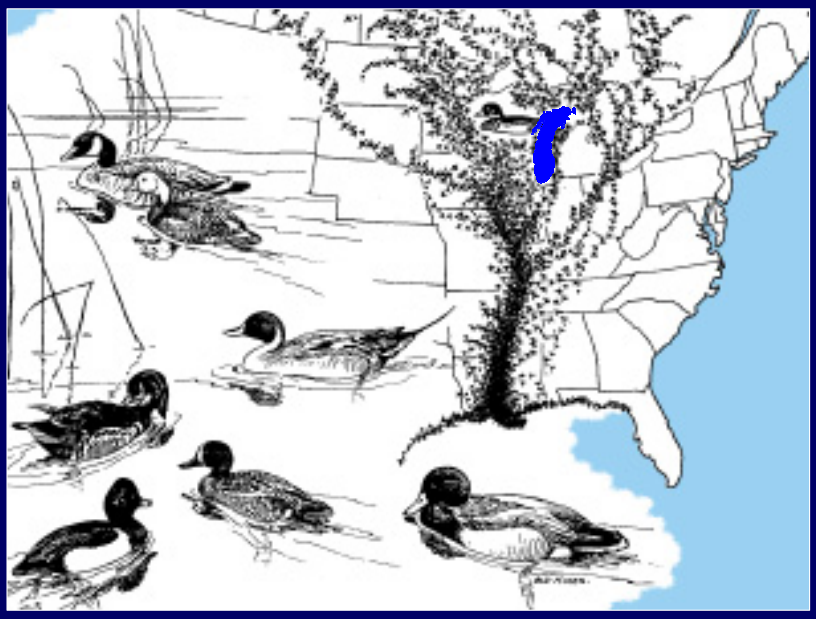
This slide shows maximum, minimum, and average historic water levels for Lake Michigan as well as the current year's lake level through September in blue. There has been considerable interest in water levels for all of the Great Lakes recently. The decrease in precipitation over the last five years and milder winters resulted in Lake Michigan being at its lowest point since 1966. The lower lake levels have caused problems for the shipping and boating industries. Cargo ships were forced to lighten their loads, and many boat ramps became inaccessible. Reports for summer 2004 indicate that the lake is at about average due to increased rainfall early in the year. The lake is about 0.3m higher than the summer of 2003 at about the mean of 176.4m above sea level.

In addition to human-built structures such as boat ramps and piers, lake levels also impact wetlands which have a vital role for many Great Lakes species.

Understanding and acceptance of the cyclic nature of the lake water levels is important for sustainable management of the coastal areas. The shoreline needs to be managed with high and low marks in mind.

Lake Michigan contains the world's largest collection of freshwater sand dunes and associated beaches, particularly along its eastern shore. Of a total of 1,250 hectares of beaches, about one third are publicly owned while another one third are privately owned but have significant potential for public use. In addition to swimming advisories due to water quality, there has been a resurgence of the macroalgae *Cladophora* along the coast. *Cladophora* blooms result in reduced water quality and beach use. Causes of the problem may be multiple factors, including lower lake levels, increased water temperature and near shore nutrients as well as zebra-mussel activity that increases water clarity allowing sunlight to promote algae growth. (Great Lakes Water Institute, University of Wisconsin, and Milwaukee).

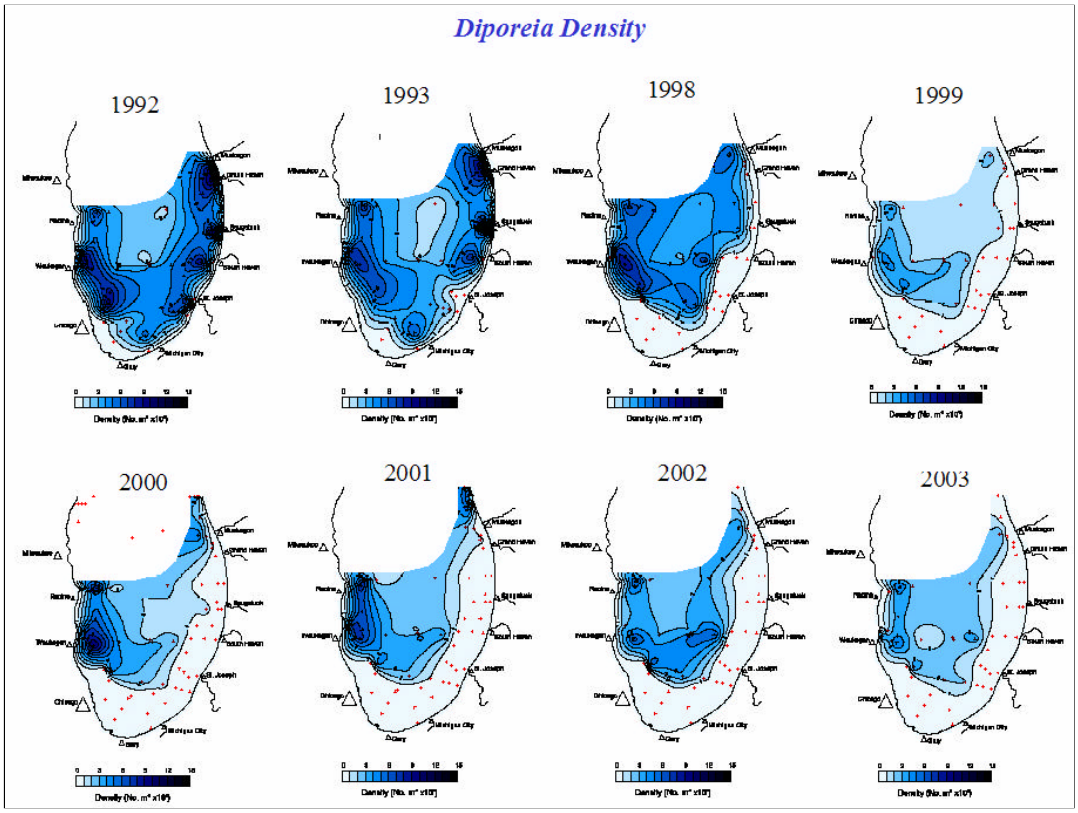
Flyways



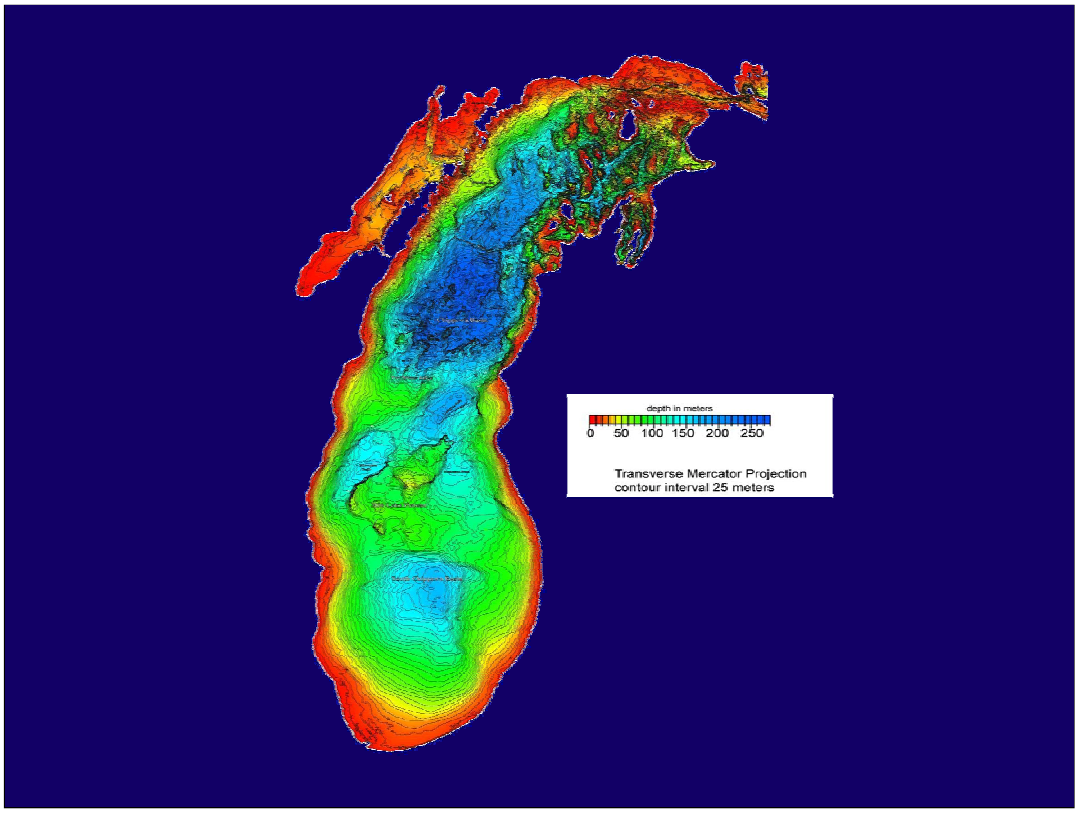
Another important aspect of Lake Michigan is its importance for migratory birds. Important flyways surround the Lake and reflect the value of coastal ecosystems, especially wetlands.

Keystone species in Lake Michigan food web vanishing

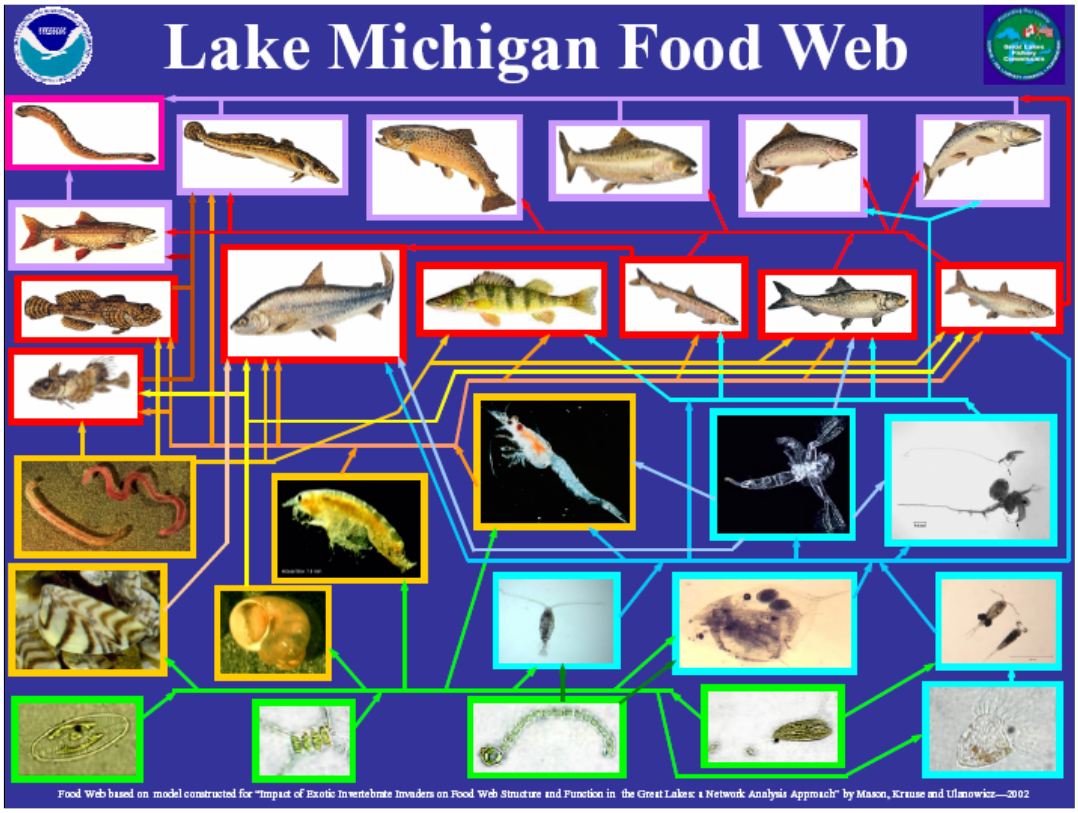
Diporeia, also known as scuds, sideswimmers, beach hoppers, and sand fleas, belong to the group of invertebrates called amphipods and are about 1.25 centimeters long. *Diporeia* have inhabited Lake Michigan since the Great Lakes were formed. They are environmentally sensitive, thriving only in clean, cold, well-oxygenated water. *Diporeia* are consumed by a variety of Great Lakes fish and provide an important energy source because they contain high amounts of fat.



Diporeia have suffered a dramatic decline in Southern Lake Michigan as indicated by this slide. The density of diporeia was considerably greater in 1992 than a decade later. The decline was particularly acute nearer to shore where nutrients, pathogens, and contaminated sediment are more likely to cause impairments.



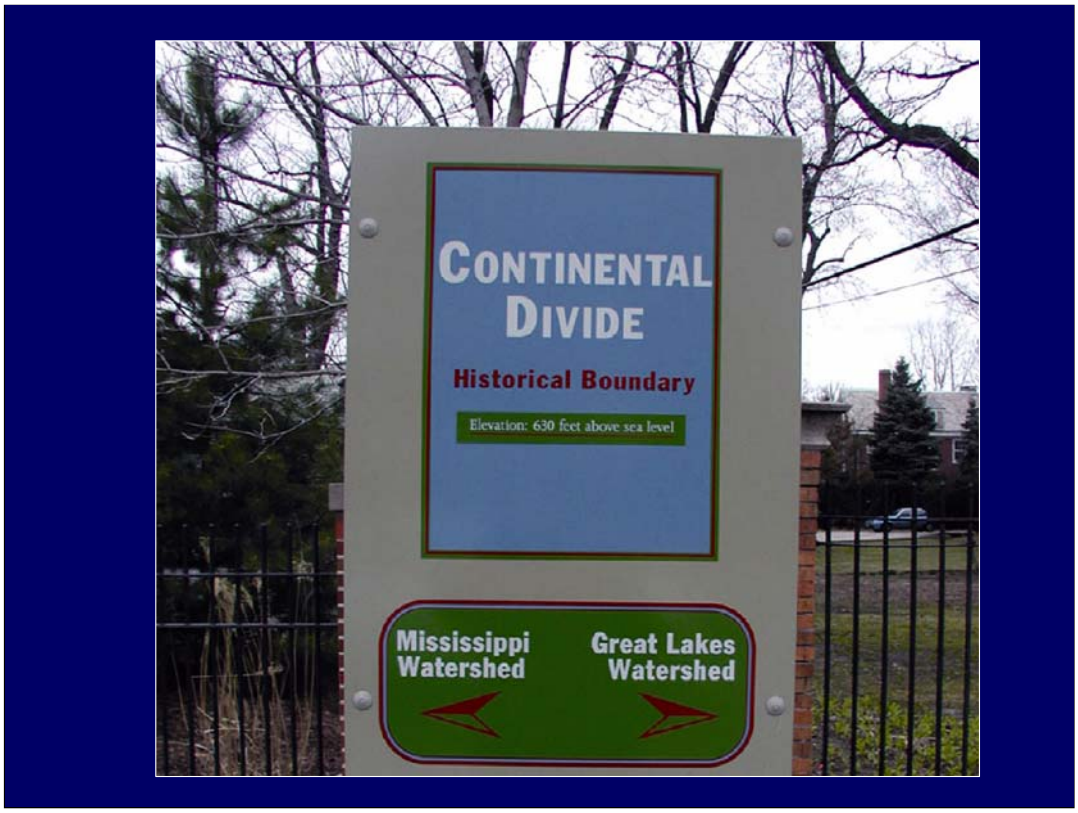
Impairment in the shallow water nearer the coastal zone is a fairly common theme in Lake Michigan. In general, in the deeper water parts of the Lake generally conditions have been improving whereas in the shallower coastal waters conditions have either not improved or, in some places, deteriorated.



Diporeia are an important part of the complex Lake Michigan Food Web. They provide food for the fish on the second line of this illustration of the food web in the red squares, which, in turn, are the prey for the large predator fish like Salmon and Lake Trout at the top of the chart.

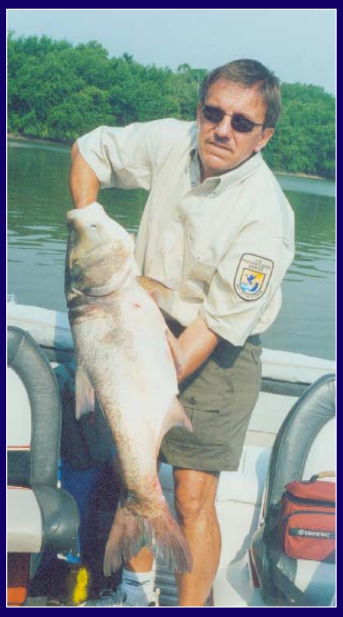
The Lake Michigan Aquatic Foot Web is threatened due to invasive species competition for food and changing the physical environment. Since 1989, zebra mussels have competed with native species for nutrients, clogged intake pipes and filtered the water allowing sunlight to penetrate the clearer water to greater depths, possibly causing algae blooms. The invertebrate *Diporeia* is decreasing rapidly in Lake Michigan thus removing a foundation component of the food web. Zebra mussels may be playing a role in the *Diporeia* decline

Invasive species may also impact other fish species in Lake Michigan. For example, an early invasive, Sea Lamprey have recently increased in abundance and Lake Trout are still not reproducing naturally.

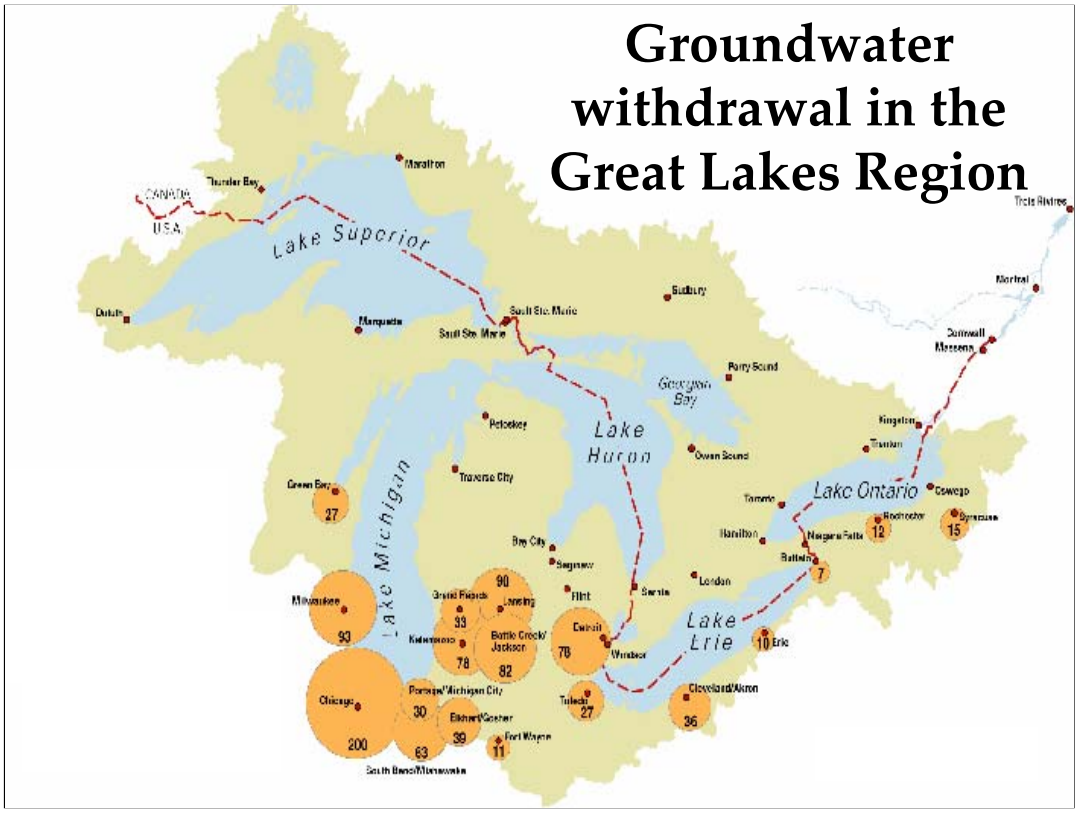


The monument in this slide marks the surface location of a point on one of the Nation's most important drainage divides demarking the place west of Lake Michigan where surface water to the left of the monument flows to the Mississippi River and water to the right of the monument flows to the Great Lakes. Watershed delineations have taken on new significance because of the engineering and ecosystem implications associated with them.

Bighead carp near La Salle, IL Summer 2002

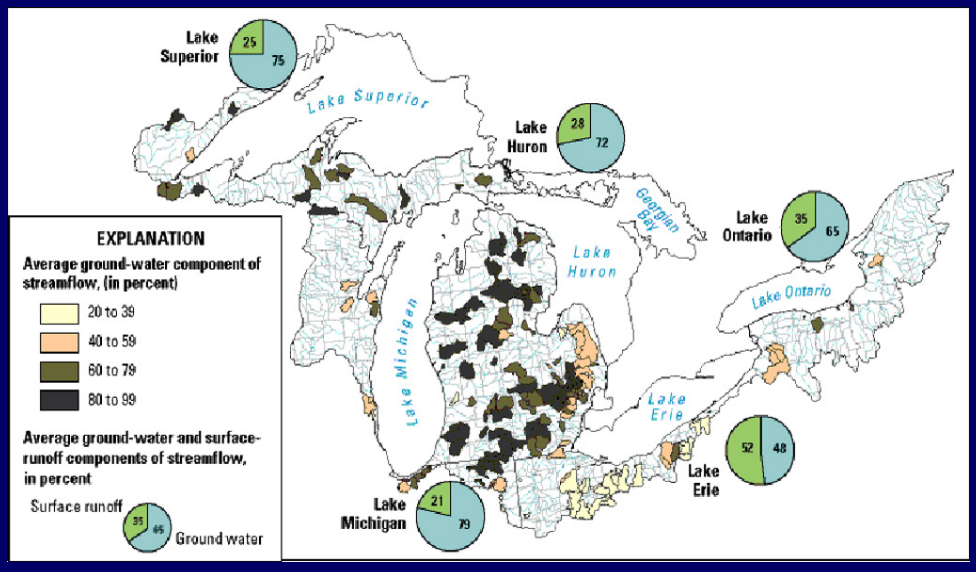


For example because of an engineered connection between the Mississippi River and Lake Michigan drainages, one of the most dramatic (but, fortunately, unrealized) food chain threats to Lake Michigan is working its way up the Illinois Waterway system from the Mississippi River. These are Bighead Carp, an invasive species that was accidentally released from fish farms during the 1993 flood. These large carp species, which weight up to 90 pounds, are considered a major threat to the entire Great Lakes food web. As a result of this and other threats, the food web status is mixed deteriorating (LaMP 2004). Fortunately, an experimental electrical barrier is in place to prevent the invasion to the Great Lakes from the Chicago Sanitary and Ship Canal. Thus we have an example of how an engineered structure has created a potential pathway for invasive species due to breaking the natural divide.



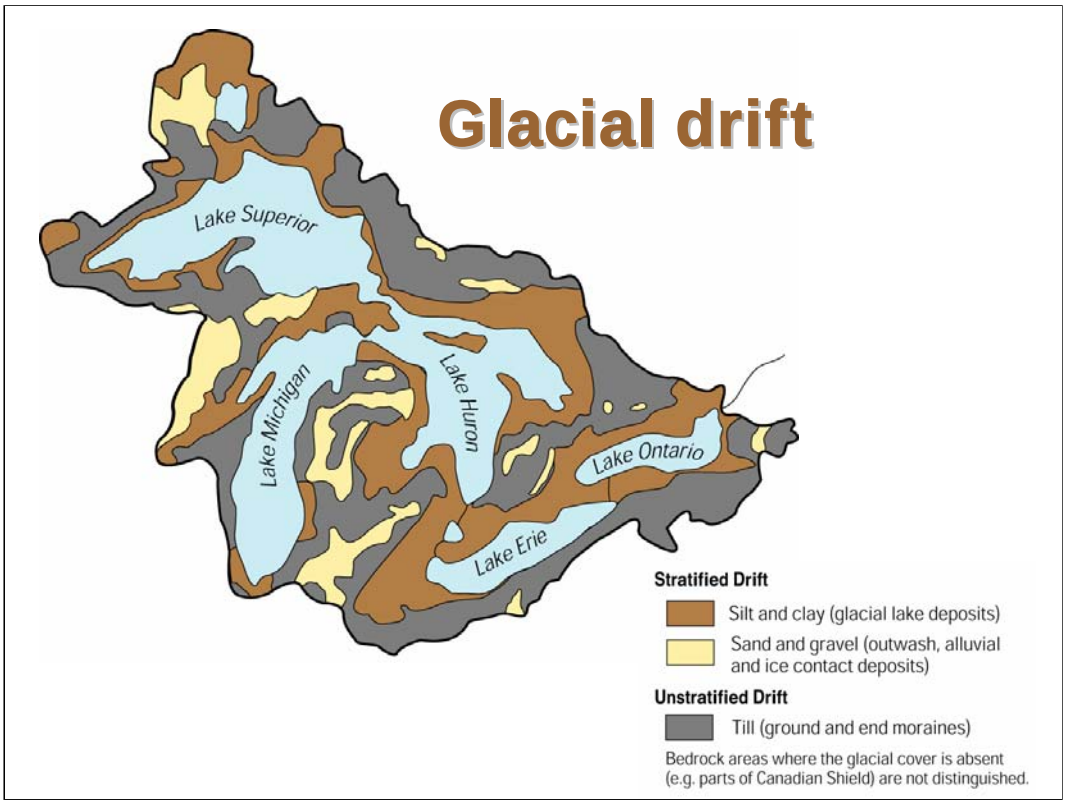
Underground, other hydraulic divides also separate ground water flowing toward Lake Michigan from water flowing away from the Lake. These divides are more complex than the surface-water divide and vary with stress on the ground-water system. The largest human induced stresses on ground water are pumping from wells for water supply and various forms of drainage such as tile drains. Withdrawal of ground water for equivalent uses in the Lake Michigan watershed is about one third of surface-water withdrawal, however, for some confined aquifers, the ground-water divide has been displaced for several kilometers as a result of the pumping. This has important implications both for the source of water to wells and for diversion of Great Lakes water.

Average ground-water and surface-runoff components of selected watersheds in the U.S. portion of the Great Lakes Basin

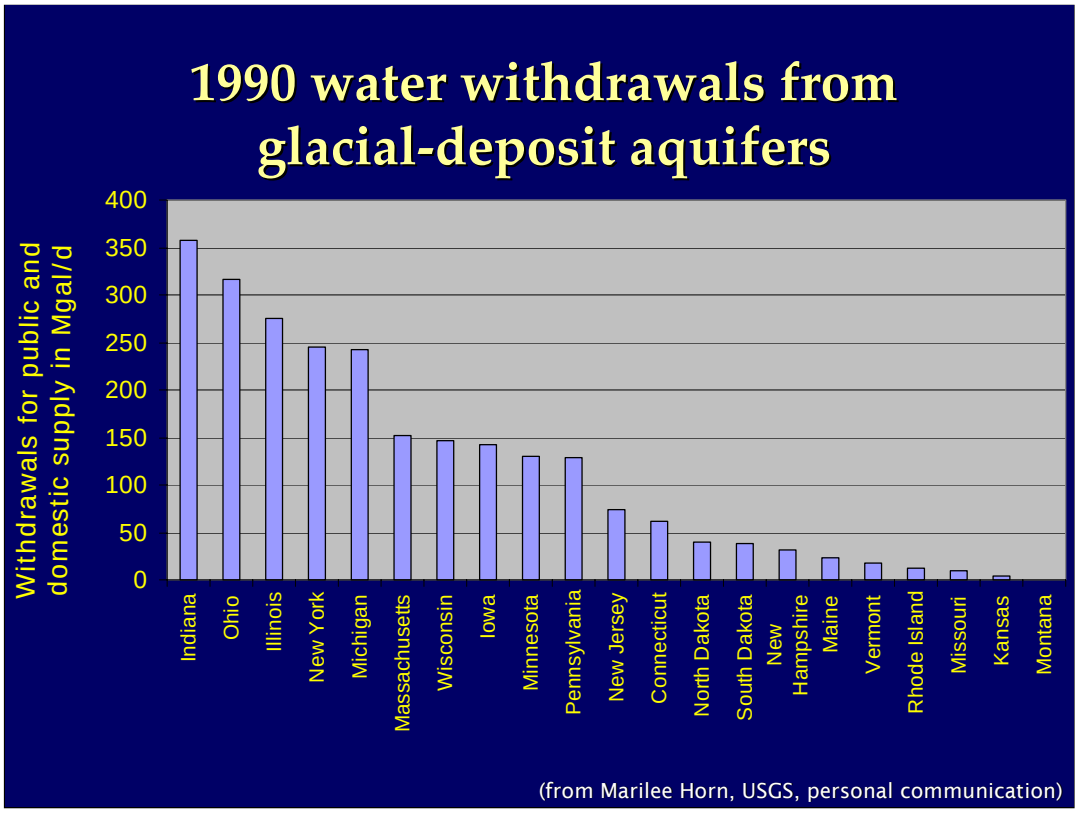


Source: Holtschlag and Nicholas, 1998

Another aspect of ground water in the Great Lakes Region that has not been generally understood is the important relationship between ground water and surface water. In almost all instances, the natural flow of a stream includes both a surface-water runoff component and a ground-water inflow component. Soon after a rainfall event, the surface-water component is dominant. As the surface runoff subsides, the ground-water flow component takes over. This slide illustrates just how important this ground-water component is in the Lake Michigan drainage. It is estimated that nearly 80 percent of the total annual flow of stream tributary to Lake Michigan originated as ground water. This water tends to be of nearly constant temperature both summer and winter and, therefore, is vital to ecosystem functions of streams tributary to Lake Michigan and to the Lake itself. It also has important implications for ground-water quality from shallow aquifers to streams and is an important but yet poorly quantified aspect for non-point sources of contamination.



Most ground-water flow to streams in the Great Lakes region infiltrates into and flows through unconsolidated glacial deposits that cover most of the region. This slide illustrates the principal types of surficial glacial deposits that compose the region's shallow aquifers. Sand and gravel constitute the most productive aquifers, till the next most productive, and silt and clay the least productive. Given the larger amount of sand and gravel deposits in the Lake Michigan drainage, it is not surprising that ground-water flow to streams in this area is relatively high.



It is also becoming more common for water suppliers to tap the glacial-deposit aquifers as sources of water. As illustrated in this slide, all of the Great Lakes States rank high among those that utilize these shallow aquifers as sources of water. The amount of water pumped is thought to be increasing but the data to support a better analysis of water use in the area needs to be improved. (As you can see this data is from 1990.) Increased use of shallow ground water will lead to more potential conflicts related to wells and the possibility that ground-water pumping may deplete streamflow especially that portion of streamflow that is so critical for ecosystem function.

In summary we would like to leave you with a few important points that I have touched on during this talk.

First, we need to know a great deal more about the interactions of ground water and surface water. Ground water plays a much more important ecosystem function than many of us previously thought and ground-water withdrawals appear to be on the rise.

Second, we have given you a mixed report on the status of Lake Michigan. In general, the open lake is improving but the coastal areas are not.

Third, we need to know much more about the interaction of physical and biological forces in the Lake, in the watershed, and especially at the coast. No where does this show up more succinctly than with issues related to beaches.

Fourth, invasive species are very worrisome and we need to know more about their impact on the food web in order to more fully understand their effects.

Lastly, underlying much of what we have discussed today, there are some vital natural areas in the Lake Michigan watershed that need protection in order to help us find the road to sustainability that we are seeking.

Obviously, I can't know all of this stuff about Lake Michigan and I want to thank the people and agencies listed on this slide for their help in preparing this overview of the state of Lake Michigan.