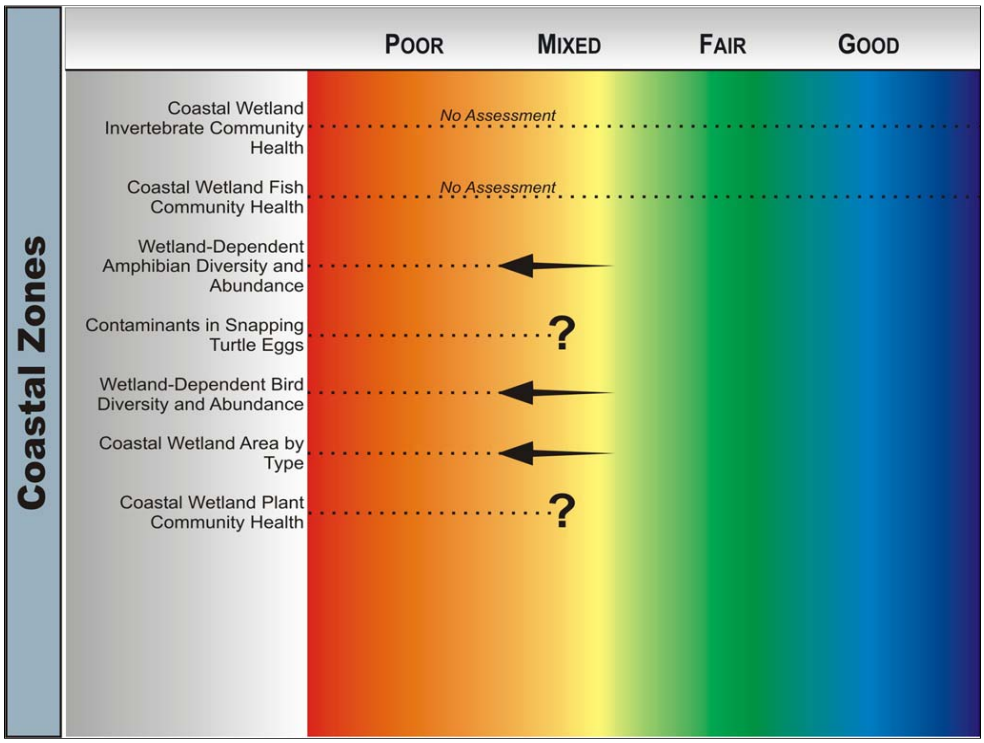
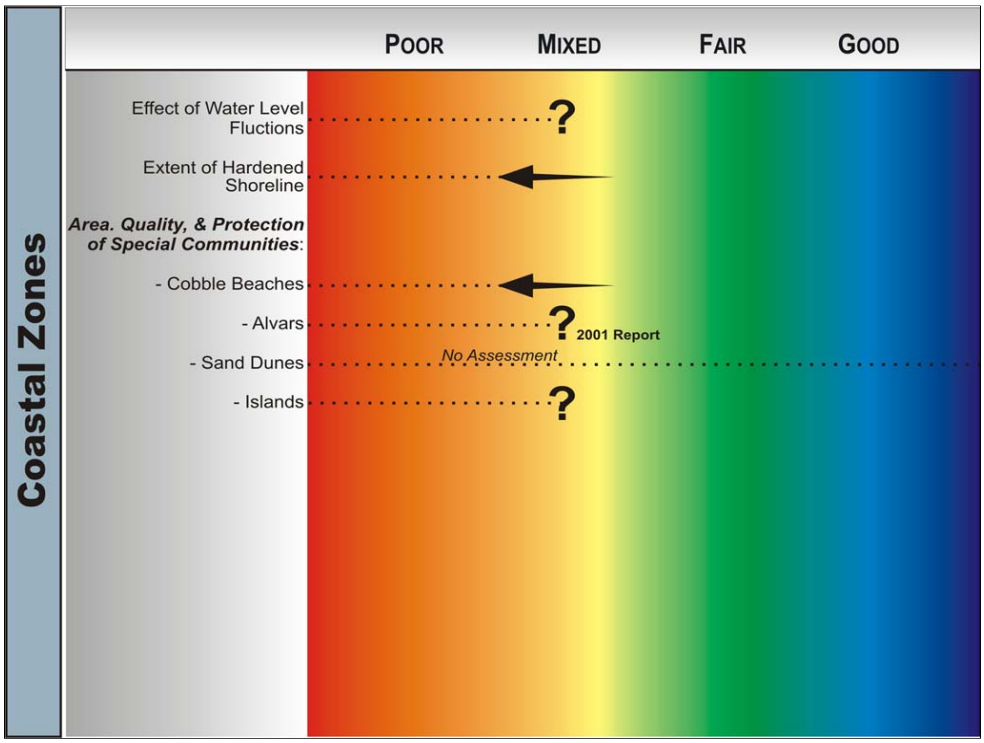

Good morning. I thank the organizers for giving me the opportunity to present at this conference. It is my great pleasure to summarize for you some of the current knowledge we have on the coastal zones and aquatic habitats of the Great Lakes. It is impossible to summarize all of this information. Hence, I will briefly cover a sample of the major findings since the last SOLEC conference. More details can be found in the supplementary material and, of course, on the web site. Before I begin, I would like to emphasize that the coastal zones and adjacent aquatic habitats are among the most interesting, important, and unique regions of the Great Lakes and the World. Consider this – more than 60 % of the World's population lives in coastal areas and this percentage is increasing. More than 90 % of the World's fish are harvested within coastal regions. More than 25 % of the World's biological production occurs within the coastal region. The coastal zones and associated aquatic habitats are extremely important and we need to make sure their integrity is maintained.


The Great Lakes coastline is more than 17,000 kilometers long – that is more than 10,000 miles for those of us in the US. The coastline still includes more than 200,000 hectares of coastal wetlands (that is about 500,000 acres), even though more than half of the wetlands have been lost. Unique habitats of the Great Lakes include more than 30,000 islands; over 950 kilometers of cobble beaches, and 30,000 plus hectares of sand dunes. This represents the largest collection of these freshwater systems in the world. The region is richly endowed with a broad range of unique and valuable fish and wildlife communities. It includes many globally rare species such as the piping plover and pitchers thistle. The region is also heavily populated, more than half of the basin's 35 million people live along the shoreline. It is here where recreational and economic opportunities are common and access to 20 percent of the world's fresh "surface water" is readily available.



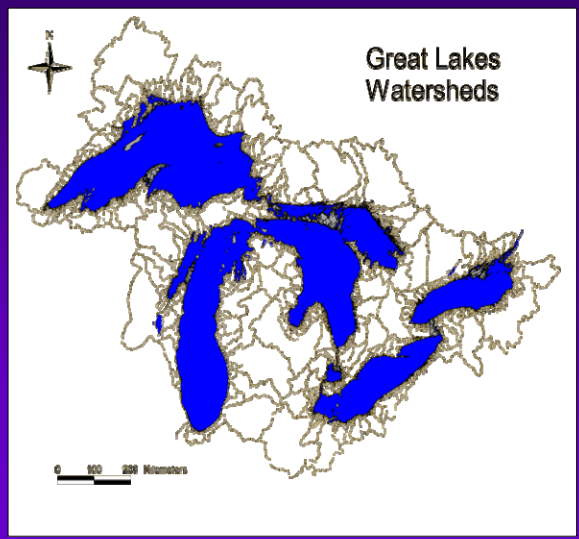

The overall status of the coastal zone is mixed and the trend is currently either deteriorating or undetermined based on the overall analysis of all the indicators included in this category. Today I will summarize amphibians, birds, and present some information on coastal wetlands.



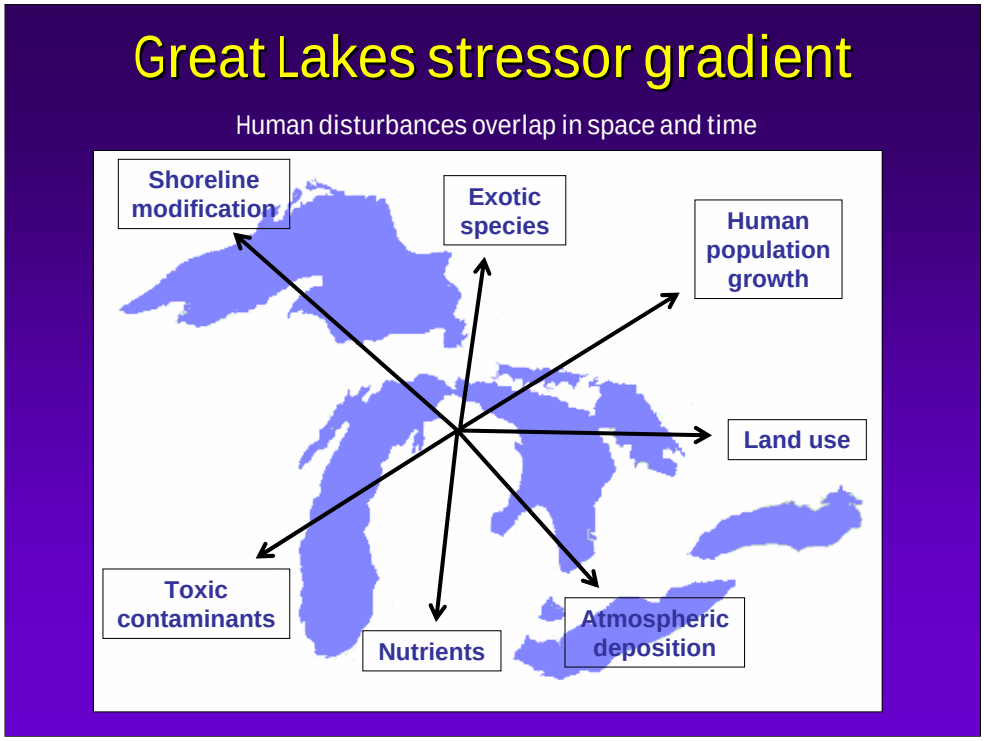

In addition, I will briefly summarize water levels and shoreline hardening. Each of these are extremely important to coastal regions.

## Defining the "population" of geographic units in the Great Lakes coastal zone

- Coastal region has diverse habitats
- Each watershed is subject to a unique combination of stressors
- Today, information is readily available for each of these units

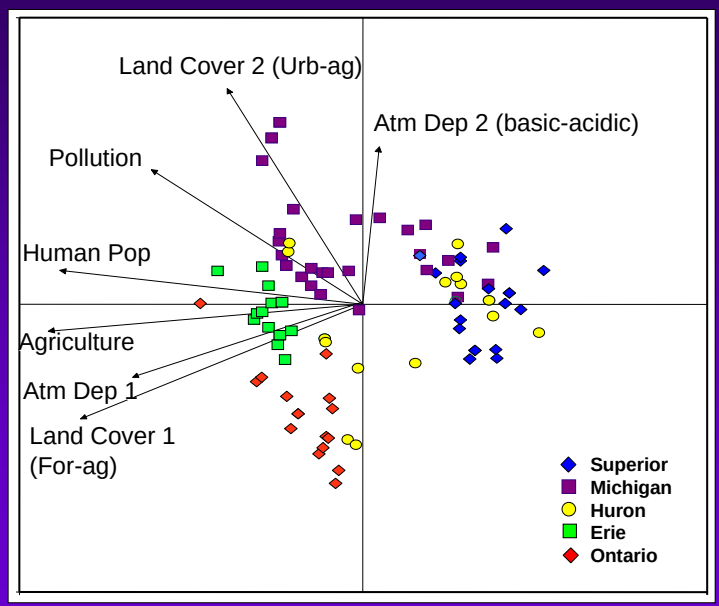



An important advancement in the Great Lakes coastal zone has been the definition of geographic coastal units. The coastal zone consists of many different habitat types such as rocky shorelines, wetlands, sandy beaches, and urban areas. Each of these coastal regions is subject to unique combinations of human and natural stressors such as agriculture, residential development, point and non-point sources of pollution, and different weather patterns. With the tremendous growth of information, data are available from a wide variety of sources and can be organized within a modern geographic information system.

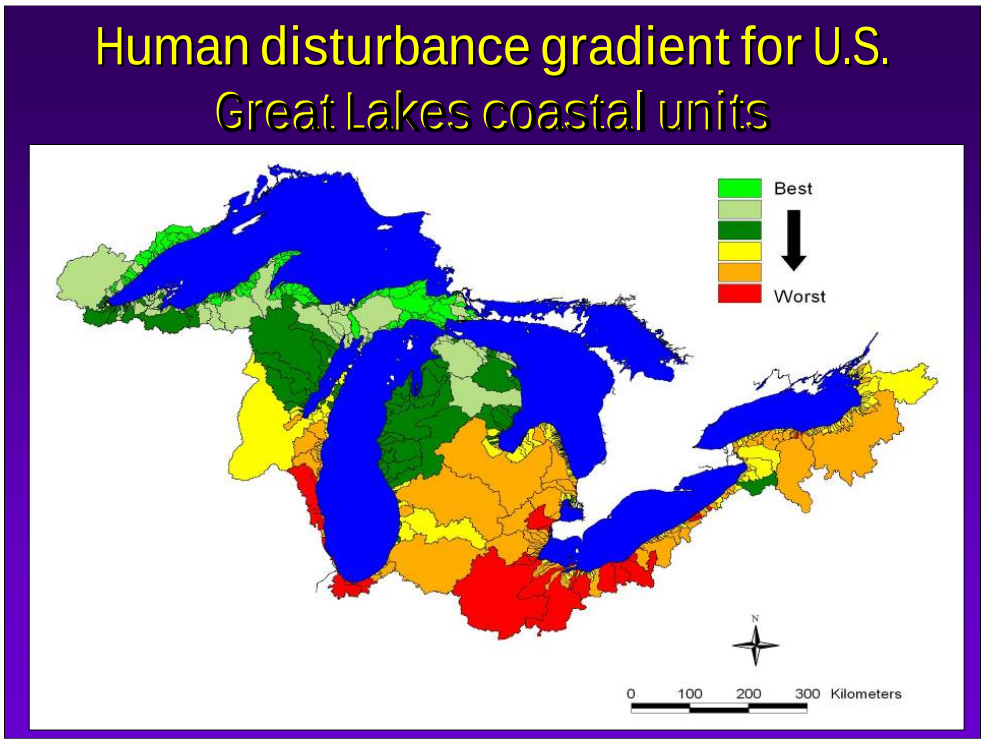



An illustration of the primary pressure indicators found in the Great Lakes ecosystem is shown here. Note that this is a conceptual diagram and the length of the vectors is not relative to their importance. The major pointis that these stressors overlap in both space and time - they are not mutually exclusive. Many areas with high human population densities also are adjacent to agricultural regions as well as point and non-point sources of pollution.

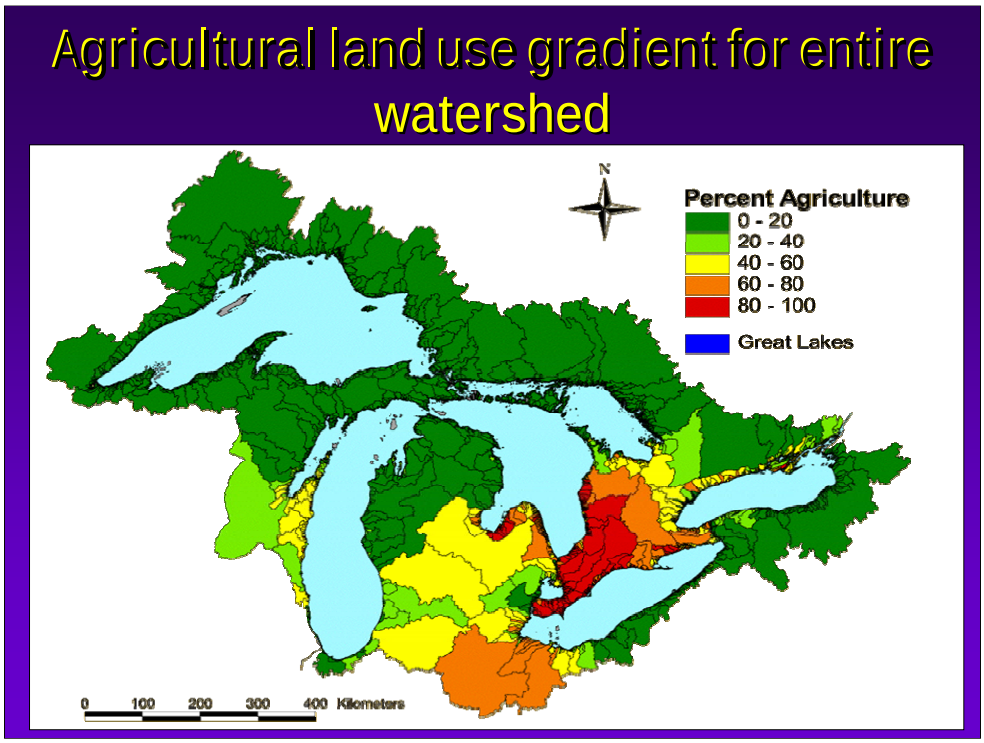
# Stressor gradients are organized by lake




These stressors can be mapped within geographic areas. For example, Lake Superior, shown in the blue diamonds on this figure, is the least stressed of the Great Lakes due to its low human populations, minimal agricultural regions, and it is surrounded by the most natural vegetation. In contrast, Lake Erie, shown as green squares, is among the most stressed because of the high population densities and large agricultural regions within its watershed. Both Lake Michigan (the purple squares) and Lake Huron (the yellow circles) span a considerable portion of the stressor gradient because of their large latitudinal variation.

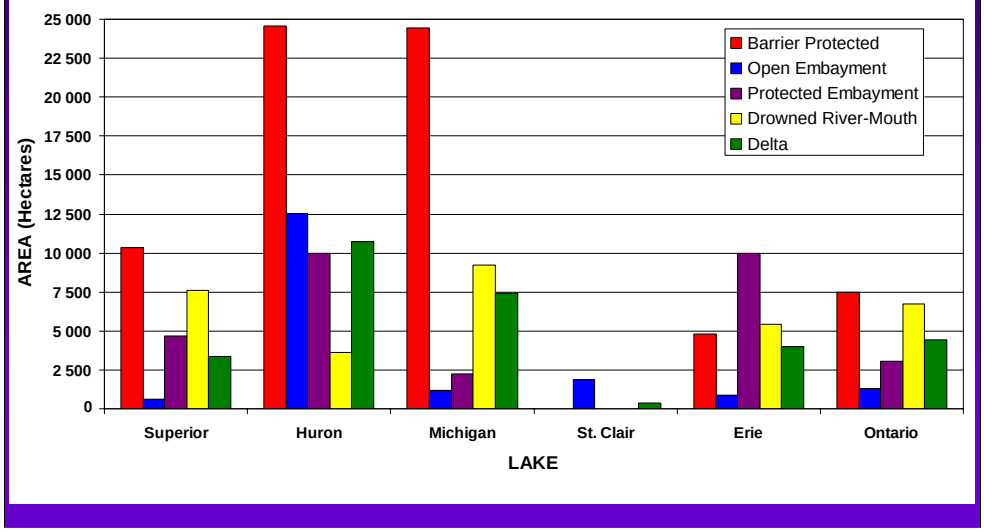



A new index of overall ecological condition of the Great Lakes coastal region has recently been mapped. Areas that are described as in the worst condition are those areas with high levels of human-related stress such as agricultural activity, high human population densities, and both point and non-point sources of pollution. The data used to generate these maps can be gathered and mapped at regular intervals such as five to ten years in order to identify those areas that are improving or deteriorating. In addition, responses by many biological communities such as amphibians, birds, diatoms, fish, and wetland plants have been related to these gradients. These relationships allow the potential to diagnose causes of changes among these communities and, ultimately, to apply corrective management action to improve conditions in the coastal zone.

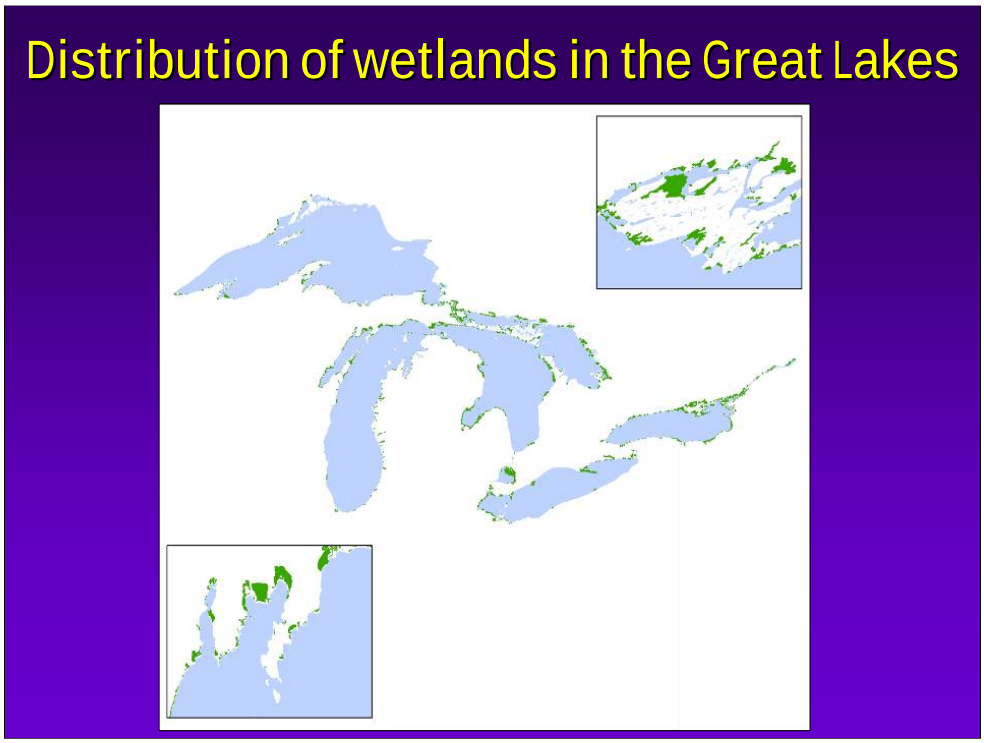



Recently, this human disturbance gradient has begun to be developed for the Canadian side of the Great Lakes also. Illustrated here is the percentage of agriculture in the entire Great Lakes watershed. Clearly agricultural activity is concentrated in the southern areas of Lake Michigan, Lake Huron, and the western region of Lake Erie. The northern regions of the watershed in Michigan, Wisconsin, Minnesota, and northern portions of Ontario are predominantly forested.

# Completed inventory of coastal wetlands by type



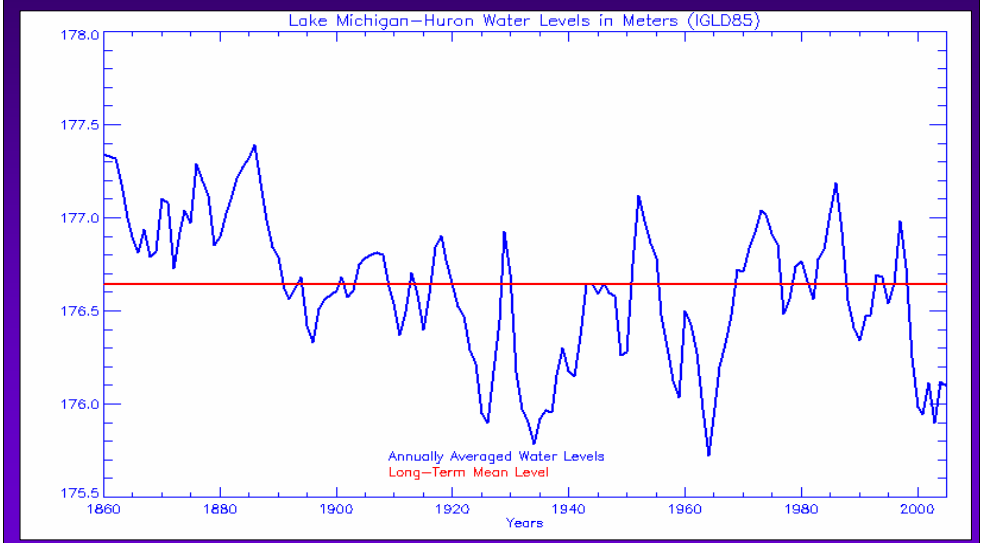

One of the problems in past Great Lakes coastal issues has been the lack of a good inventory of the wetlands in the coastal region. Wetlands, once thought as unimportant, are now recognized as essential for proper functioning of ecosystems. In 2004, a seamless inventory of Great Lakes coastal wetlands was completed for all of the Great Lakes and Lake St. Clair. The results indicate that Lake Huron and Lake Michigan still have extensive wetlands, especially barrier protected wetlands. This inventory will provide a solid basis for future comparisons of changes in wetlands over time. This inventory will need to be completed at regular intervals, likely using remote sensing imagery, to detect future changes in the distribution and abundance of these important wetland systems.




The general distribution of wetlands in the Great Lakes is shown here in green. Note the extensive wetlands in Lake Huron, Georgian Bay, northern Lake Michigan, and northern Lake Ontario.

# Water level fluctuations

## Lake Michigan – Lake Huron (1860 to 2005)



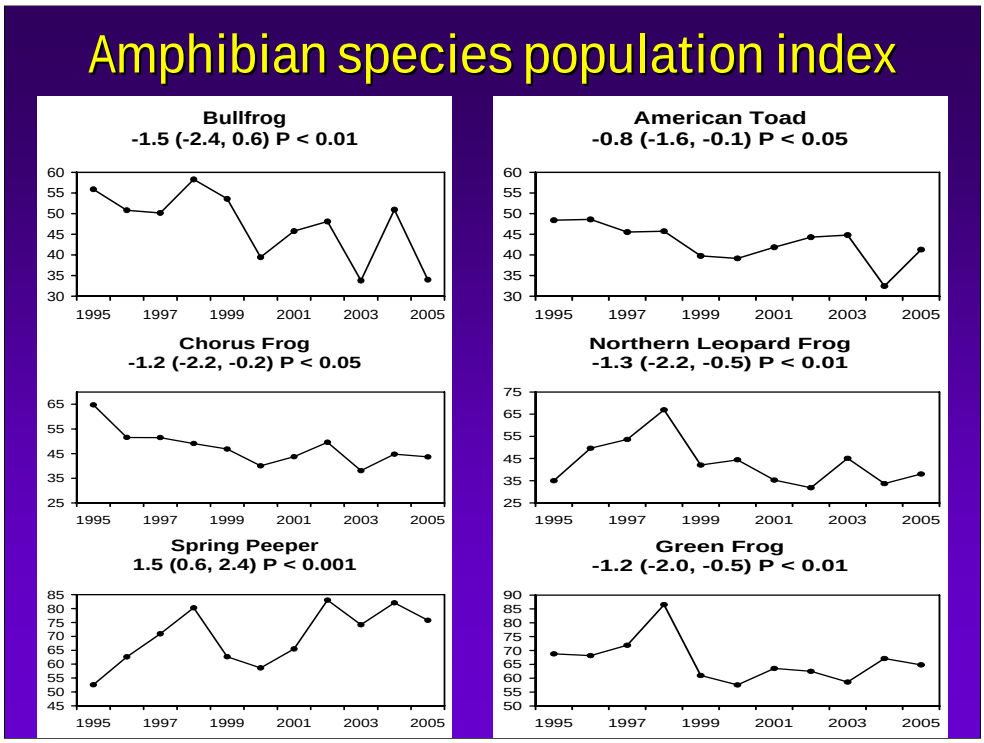

Water levels have a tremendous influence on coastal zones, especially wetlands. These fluctuations also have cascading effects on plant communities and the entire biota found within wetlands. In general, water levels remain lower than the 140 year average such as shown here for Lake Michigan and Lake Huron. In addition, many climate change models predict lower precipitation for the Great Lakes region and, hence, reduced water levels are predicted for the future.


The coastal wetland fish community indicator is under development and should be implemented over the next 2 years. Fish communities have been and will be important indicators to society. Fish species are heavily influenced by plant communities and are affected substantially by human activities. There are many non-native species of continued concern that have been in the Great Lakes for considerable periods such as the common carp and goldfish. In addition, there are many concerns with in invasions of other non-native species such as the grass carp, the bighead carp, silver carp, and black carp. Each of these species have a potential pathway to the Great Lakes via the Chicago Sanitary Canal. A bit of good news --- several recent studies suggest that wetlands provide refugia for many native species, especially when non-native species such as round goby and Eurasian ruffe are present.

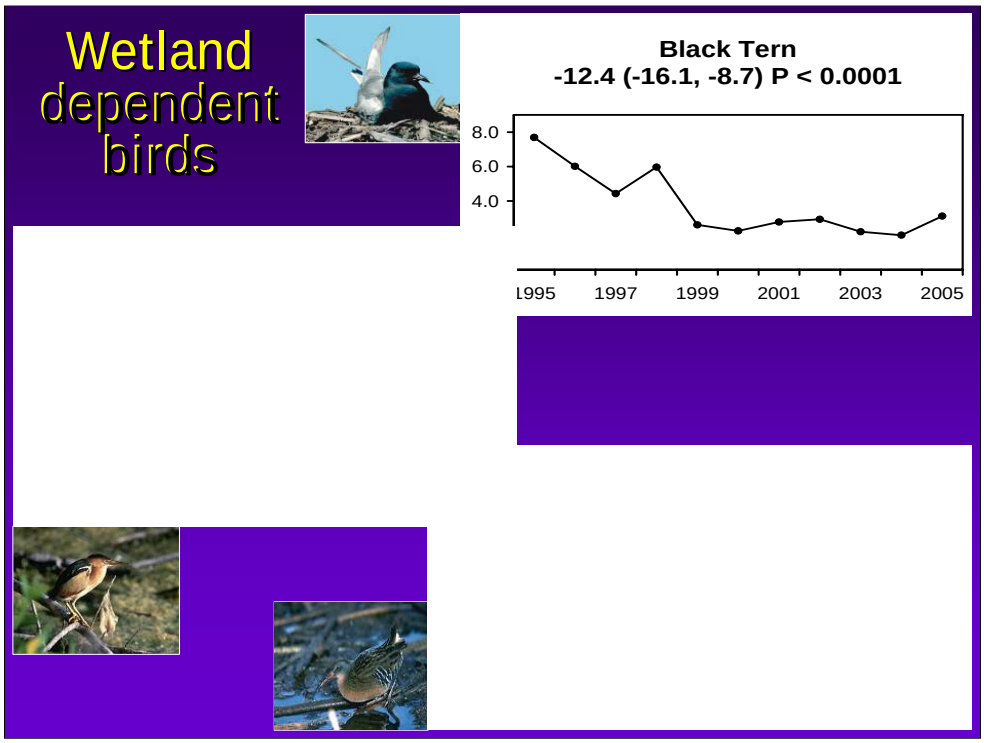
## Coastal wetland plant community health

- **Status – Mixed; Trend – Undetermined**
- **Water level fluctuations render monitoring difficult**
- **Non-native species are a continuing concern**
- **Potentially slow progression of non-native species to the west**

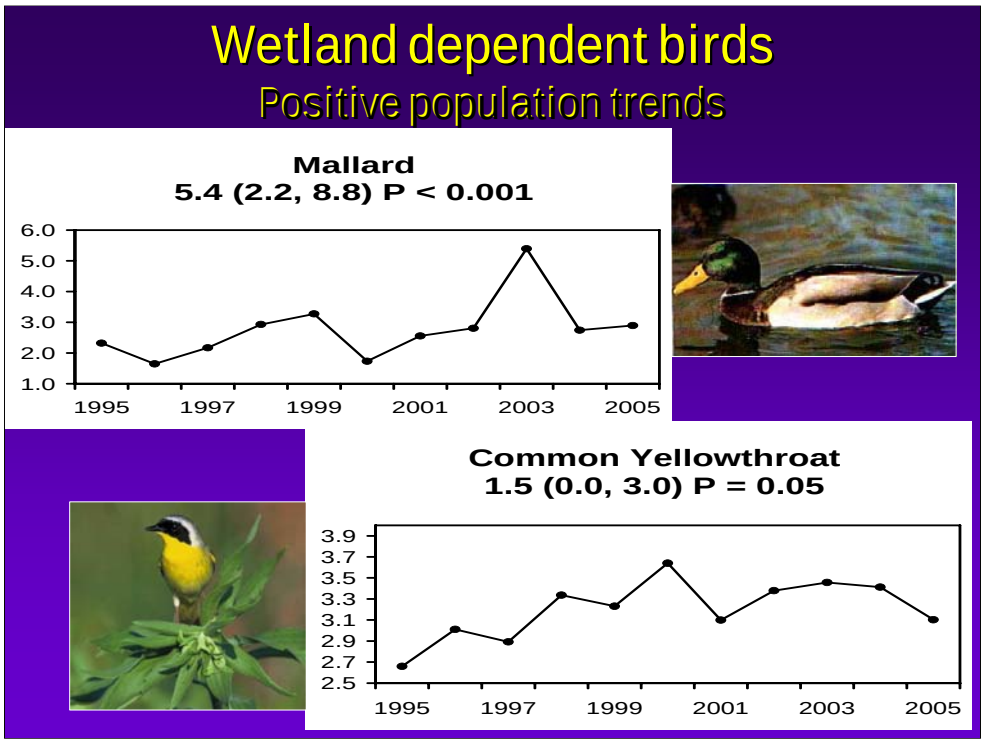
The status of coastal wetland plant communities is mixed and the trend is undetermined. Changes in Great Lakes water levels have profound impacts on wetland plant communities and renders monitoring these communities difficult. There is a continued concern in the invasion and spread of non-native plant species such as reed canary grass, purple loosestrife, and water milfoil. There appears to be a slow progression of many non-native species to the west because introductions first occur in the eastern regions. Wetland plant communities continue to be affected by agriculture, urban development, and other alterations such as diking, ditching, and filling of wetlands.




The changes in the amphibian population indices shown here from 1995 to 2005 were based on the Marsh Monitoring Program. Overall, the status is described as mixed to poor, with a deteriorating trend. Six species of amphibians have shown a significant change in their populations from 1995 to 2005. Five species, the bullfrog, American toad, chorus frog, Northern leopard frog, and green frog, have significantly declined during this period, while the spring peeper is the only species to show a significant increase. Note that the decreasing trend in the Northern leopard frog and green frog are substantially influenced by high counts in 1997.

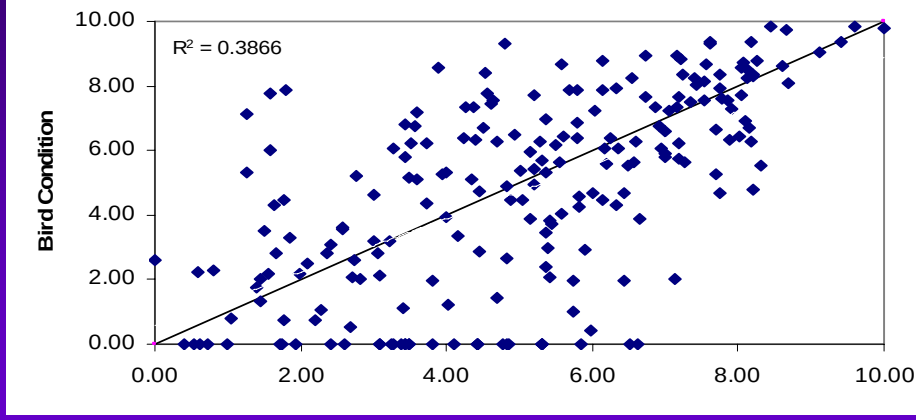



Over 130 breeding bird routes were surveyed each year from 1995 to 2005 by volunteers in the Marsh Monitoring program. A total of 54 bird species were identified that use wetlands. The results for the 11 years of counts indicate that 14 species have negative population trends and six species have positive population trends. Shown here are three species with negative trends. Each of these species is dependent on wetlands and each has been identified as a species of concern. Concerns for these species are related with their relatively small populations and their negative trends within much of their range.




Two common species, the Mallard and Common Yellowthroat, are also found in wetlands and they are increasing, according to the Marsh Monitoring Program. The Mallard has adapted to the use of human-dominated habitats, especially in urban and semi-urban areas. The Common Yellowthroat is found abundantly in cattail and shrubby wetland ecosystems as well as many early successional forests. These habitat types continue to be relatively common in the coastal region of the Great Lakes.

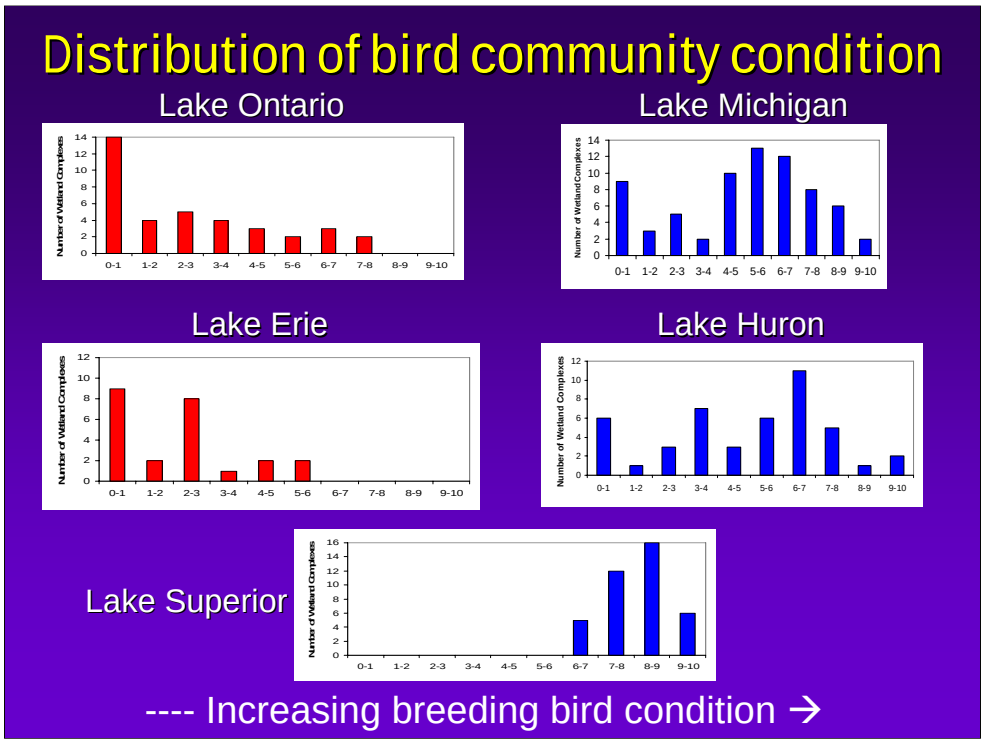
# Breeding bird communities in wetlands are related to the human disturbance gradient




--- Human Disturbance Gradient →

--- less human disturbance, increasing natural habitat →

Bird condition has been related to reference condition in a sample of over 200 wetland sites across the US Great Lakes coastal region. Increasing values of reference condition (from left to right) is related with more natural conditions and reduced impacts from human disturbance. Note, however, that many breeding bird communities in the upper left are in relatively good condition despite heavy human disturbance, while few sites in the lower left of the figure have low condition when human disturbance is low.




A summary of these relationships----that is the breeding bird condition of wetlands for each of the five Great Lakes is shown in this figure. Lake Ontario and Lake Erie show the poorest breeding bird condition and Lake Superior wetlands have the best condition for breeding birds. Lake Michigan and Lake Huron cover a wide variety of conditions which reflects their extensive latitudinal variation. In these lakes, many of the wetland complexes in the northern regions have relatively good condition, while those in the southern regions have conditions similar with Lake Erie and Lake Ontario.

# Coastal land use change in the U.S. Great Lakes

- **Land use change in 1 km buffer shoreline indicated that 4.8% (76,555 acres) was converted from 1992 to 2001**
- **Largest permanent changes were**
  - **Forest land to developed land (21,383 acres)**
  - **Agricultural land to developed land (9,719 acres)**

Even though we do not have a good indicator for the land use adjacent to wetlands, a recent analysis for a 1 km buffer across the US Great Lakes coastal region provides some indication of changes in the coastal region. A total of 4.8 percent of the land use in this 1 km buffer changed from 1992 to 2001. The largest changes were observed in conversions from forest land and agricultural land to developed land. More than 21,000 acres of forest land were converted to developed land and more than 9,000 acres of agricultural land were converted to developed land. Developed land was primarily residential, urban, and industrial land area.

## Extent of hardened shoreline

- **Status – mixed; Trend – deteriorating**
- **Primarily via erosion control structures**
- **St. Clair, Detroit, and Niagara Rivers have the highest percentage of shoreline hardening**

The status of hardened shorelines is mixed and the trend is deteriorating. Hardening of Great Lakes shorelines is a significant problem in coastal regions. These problems are primarily associated with structures that are attempting to control for erosion. The most acute problems are associated with the St. Clair, Detroit, and Niagara River areas. Public education programs will be important in reducing future shoreline hardening.

# National Marine Conservation Area of Canada (NMCA) in Lake Superior

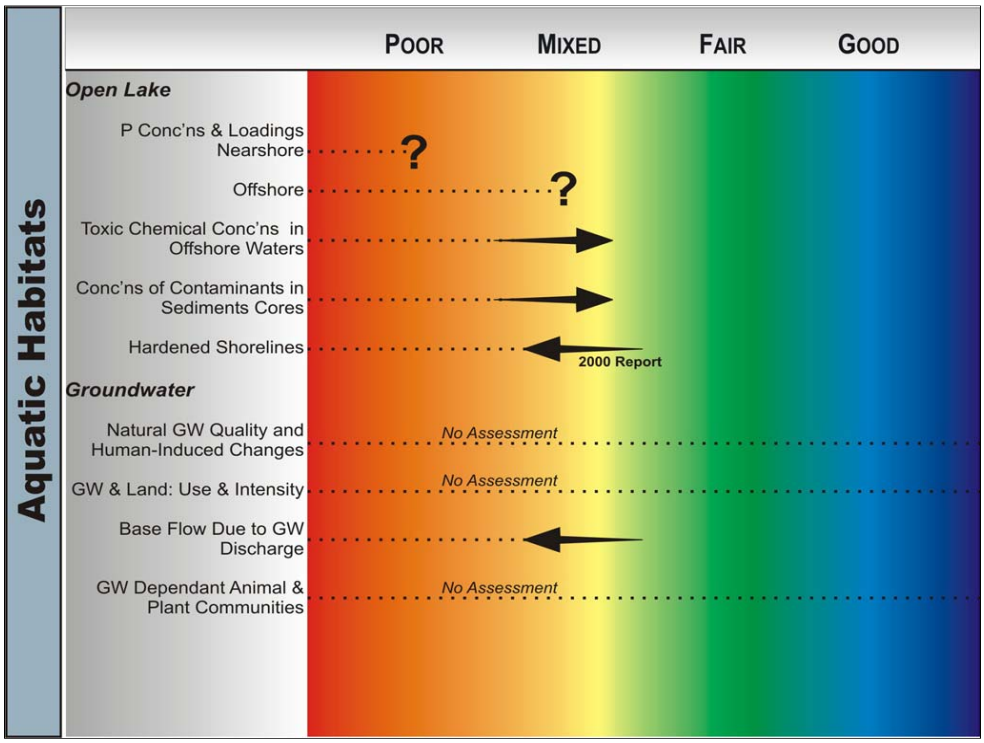

In October 2002, the Government of Canada announced an action plan to create ten new national parks and five new national marine conservation areas. Shown here is the first planned marine conservation area in northern Lake Superior. The area would extend from Thunder Cape at the tip of Sleeping Giant Provincial Park in the west to Bottle Point in the east. It encompasses 10,000 square kilometers of lakebed as well as many islands, shoals, and some of the mainland.

## Coastal zones
### conclusions

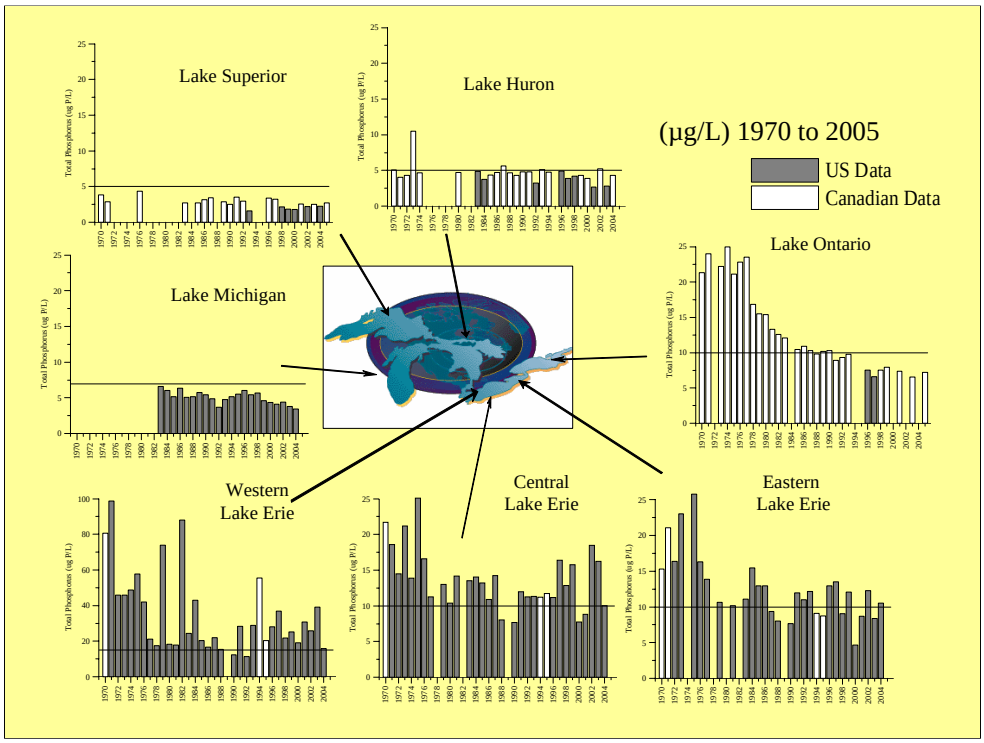
- **Most indicators have mixed status and undetermined trend in condition**
- **Need for a comprehensive plan to monitor changes**
- **Coastal zones are among the most heavily impacted areas of the Great Lakes**
- **Biota related with human disturbance gradient**

In summary, indicators in the coastal zones have shown a mixed status and most of the indicators have an undetermined or deteriorating trend in condition. The coastal zone, like many ecosystems, lacks a comprehensive plan for regular monitoring of pressure and state indicators. Shoreline hardening continues to be a cause for concern and education of the public on these issues must be a priority. Coastal zones and the associated near shore aquatic areas are among the most heavily impacted areas of the Great Lakes. Monitoring programs will be essential to maintain the condition and integrity of these regions.


There is a tremendous amount of information that can be included on aquatic habitats of the Great Lakes. Two important indicators will be reported on here - phosphorus and the base flow of ground water.

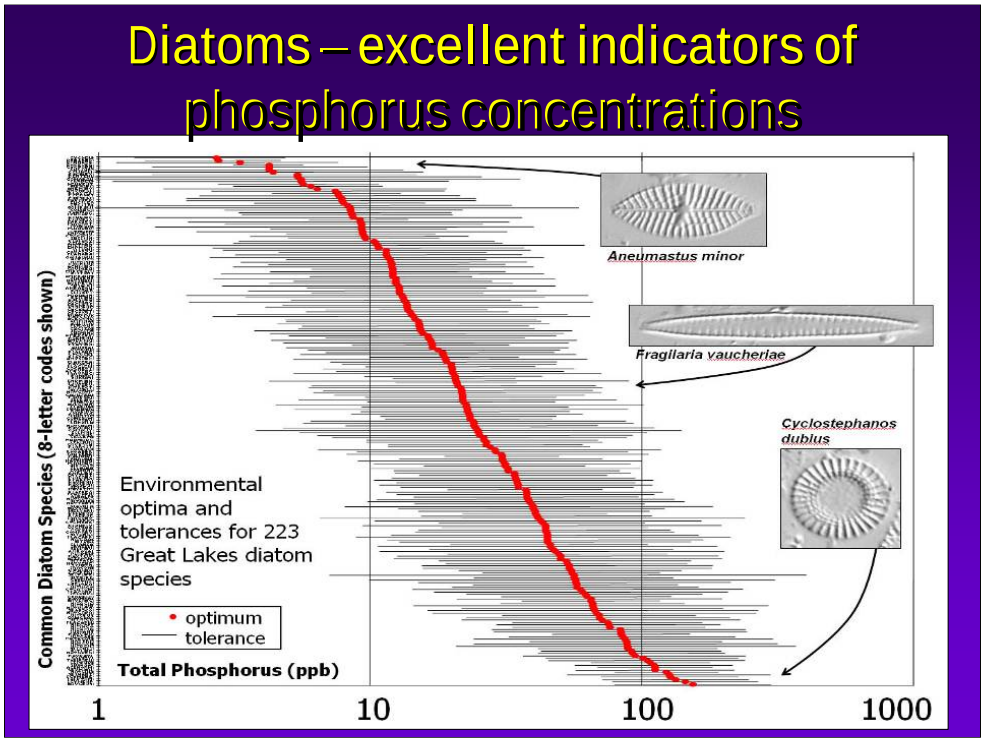



The overall status of aquatic habitats is mixed or not assessed. The trend is uncertain and variable. Phosphorus concentrations and groundwater issues will be summarized here.

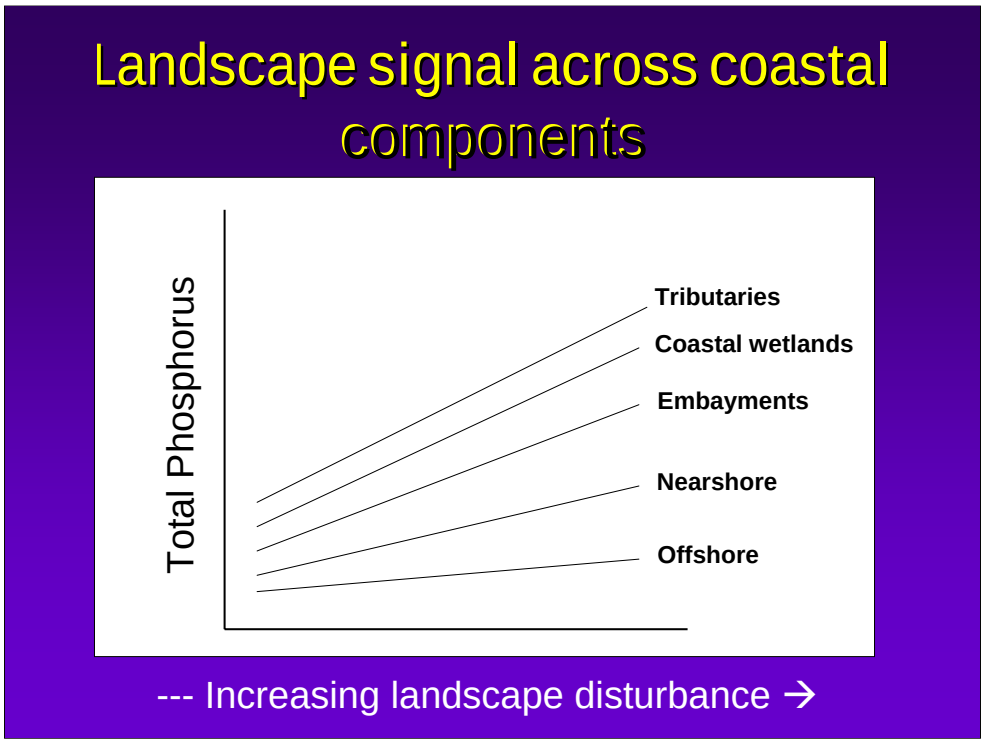



Overall efforts by management have been successful in maintaining or reducing overall phosphorus concentrations in the Great Lakes since the 1970s. This slide clearly indicates that phosphorus concentrations are highest throughout Lake Erie, but are showing a declining trend. This is also illustrated in Lake Ontario. Phosphorus concentrations in Lake Superior, Lake Huron, and Lake Michigan are all low compared with Lake Ontario and Lake Erie. However, there has been less change in Lake Superior, Lake Huron, and Lake Michigan in recent years. Phosphorus concentrations in nearshore waters are still periodically exceeding guidelines in Lakes Huron, Ontario, Erie, and Michigan. This is likely contributing to the growth of nuisance algae in these lakes.

# Diatoms – excellent indicators of phosphorus concentrations

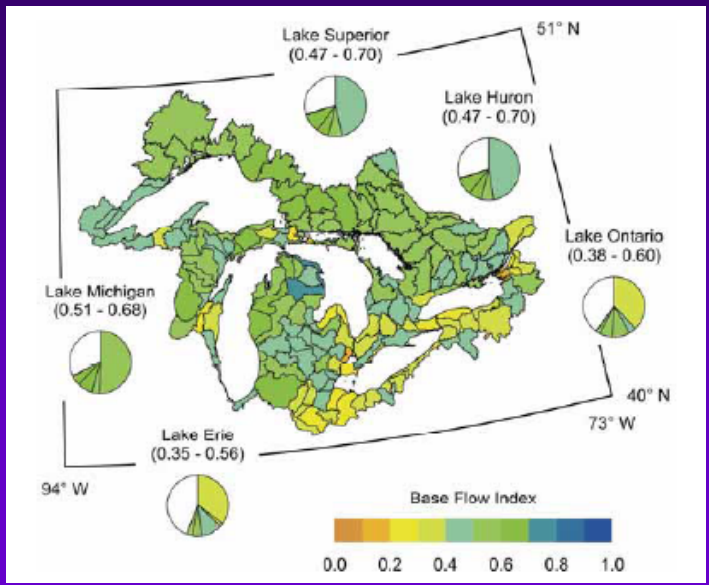



Recent studies have shown that diatoms which are microscopic organisms in water are excellent indicators of prevailing phosphorus conditions in the near shore regions of the Great Lakes. Shown here is the distribution of 223 common diatom species on the y-axis and phosphorus concentrations on the x-axis. A simple sample of diatoms can provide a better measurement of overall phosphorus concentrations compared with measuring phosphorus. This is because diatom communities are less variable compared with measuring phosphorus directly and because they are living organisms they are “integrators” of the prevailing ambient conditions. In the near shore coastal zone, water quality measurements like phosphorus can be difficult and highly variable because of the influence of flashy events such as storms.




Phosphorus concentrations in the Great Lakes are related with the surrounding landscapes. The total phosphorus concentration is expected to be highest in tributaries and lowest in offshore regions in relation to human disturbance in the watershed. As sampling efforts move from the tributaries to offshore, the degree of landscape disturbance has a decreasing influence on total phosphorus concentrations due to the effects of dilution. Hence, phosphorus concentrations are highly dependent on the places where samples are taken. Recent sampling of these coastal regions has verified these relationships.

# Base flow due to groundwater discharge




The status of the Base Flow Due to Groundwater Discharge indicator is mixed and the trend is deteriorating. Base flow due to discharge of ground water has been estimated as approximately 60 % (**let me repeat that 60 %)** for Lake Huron, Lake Michigan, and Lake Superior and 50 % for Lake Erie and Lake Ontario. On a local scale, human activities have detrimentally impacted groundwater discharge in the Great Lakes due to such activities as irrigation and the increased proportion of impervious surfaces in urban areas. On a larger scale, climate change and reduced precipitation could further contribute to reductions in ground water reservoirs. Pure and simple - groundwater is taken for granted. Ground water is critical for maintaining coastal habitats and associated biota. In addition, mapping the geology associated with ground water base flow is important for further development of this indicator.

## Aquatic habitats
### conclusions

- **Phosphorus concentrations in the open water continue to decline, but nearshore concentrations often exceed standards**
- **Education on the negative effects of shoreline hardening is needed**
- **Groundwater is critical to coastal areas**
- **Increasing human populations and climate change will further exacerbate groundwater base flows**

In summary, the status in aquatic habitats is mixed and the trend is deteriorating or undetermined. Improvements have occurred in reductions to phosphorus levels in offshore waters, but there continue to be isolated cases of levels exceeding guidelines especially in the near shore regions. There are continued concerns to base flow due to reduced groundwater discharge. Recent studies show that groundwater discharge exceeds 50 % of the base flow to the Great Lakes and these flows are being greatly affected by human activities such as irrigation and the increased proportion of impervious surfaces. Climate change may also play an increasing role in the future.

## Presentation conclusions

- **Most indicators show mixed status and either undetermined or deteriorating conditions**
- **Coastal regions are geographically unique, aesthetically attractive, and biologically productive**
- **Exceptional need for comprehensive, strategic plan to monitor the coastal zone**

The current indicators show a mixed status and either undetermined or deteriorating conditions. These are not good signals for the coastal zone or our aquatic habitats. The Great Lakes coastal zones and adjacent aquatic habitats are geographically unique, aesthetically attractive, and biologically productive. If we as a society are to keep them unique, aesthetic, and productive, then we must establish a comprehensive strategic plan to monitor and protect these regions for future generations.


A variety of groups have contributed to this summary. They are duly acknowledged and their efforts are greatly appreciated. Thank you.