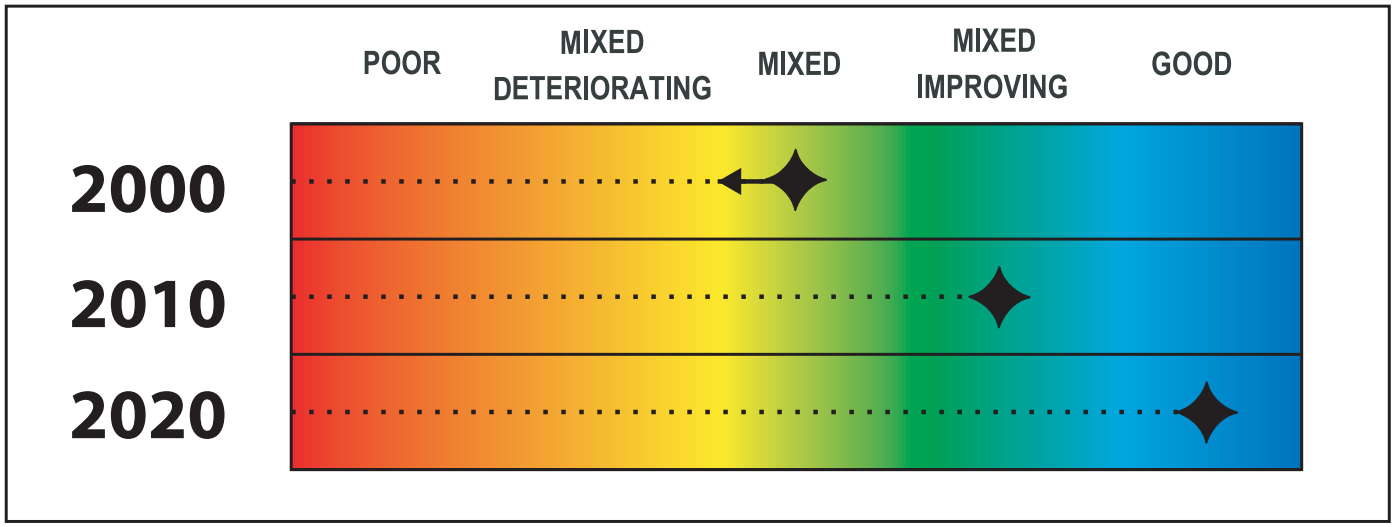
Subgoal 4
Are all habitats healthy, naturally diverse, and sufficient to sustain viable biological communities?



Status

The Lake Michigan ecosystem continues to experience profound changes because of development, impacts of nuisance species, and pollutant loading. Overall, the status of Lake Michigan habitats, including open water, wetlands (coastal and inland), coastal shore, tributaries, lakeplains, and inland terrestrial systems, is mixed to deteriorating. Many species habitats rank as globally rare or imperiled based on their restricted distribution, the level of threat, their ecological fragility, and widespread damage or because they are part of the single largest source of fresh surface water in the world. This section assesses the status of each of the general habitat types in the Lake Michigan ecosystem and highlights significant events since the issuance of LaMP 2000. This assessment includes an overview of continuing trends in habitat loss and decreased biodiversity as well as the impacts of aquatic nuisance species.

Challenge

(1) To identify and enhance, restore, or protect critical ecosystem features and habitat through purchase or voluntary protection.

(2) To make habitat information readily available.

Open Lake System

The open lake waters of Lake Michigan consist of both inshore and offshore waters, including all waters from the offshore edge of coastal wetlands lakeward. Significant changes in the lake ecosystem

Little Traverse Bay Bands of Odawa Indians Lake Trout project

The Little Traverse Bay Bands of Odawa Indians Natural Resources Department is researching the influence of egg and fry predators on the lack of successful lake trout reproduction in the Great Lakes. Predation, particularly by exotic species, may exceed the potential of spawning reefs to successfully incubate eggs and produce measurable recruitment. During the study, the Little Traverse Bay Bands have collaborated with the Canadian Department of Fisheries and Oceans, the Michigan Department of Natural Resources, and the University of Vermont. Egg, fry, and predator abundance was measured at spawning reefs using egg seeding, fry traps, and alewife exclosures. Initial findings have documented lake trout egg deposition and survival to yolk-sac fry for the first time at specific sites in northeastern Lake Michigan. Additional field and laboratory experiments will be conducted to assess the current effect of predation on recruitment.

Rise and Fall of the Lake Trout

Lake trout (Salvelinus namaycush) is a North American salmonid that thrives in cold, fresh water. Following the retreat of the last glacier, the lake trout colonized Lake Michigan, and over the subsequent 10,000 years or so, it became the top predator in a complex ecosystem that co-evolved with the other fish species. Over that period of time different strains of lake trout evolved. Some strains thrived in the deepest waters of the lake feeding on the abundant chubs and deepwater ciscoes, while other strains thrived in shallower areas.

Starting in the mid-1800s, the human population of the region began to increase, and cities started growing around the lake. With abundant resources and convenient access to waterways, Lake Michigan quickly became a major industrial hub of the United States. Commercial fishing for lake trout also became an industry, and by the beginning of the 20th century, the lake trout population was in decline. The decline continued until the mid-1950s, when predation by sea lamprey, overfishing, and the effects of industrial pollution led to the destruction of lake trout fisheries and the disappearance forever of many of the strains of lake trout that had evolved in the lake.

Currently, federal, state and tribal management agencies around the lake are attempting to re-establish naturally reproducing populations of lake trout by planting yearlings and eggs in historical spawning areas. Assessments indicate that self-sustaining populations of lake trout have yet to be established. Research into the reasons for this failure are ongoing, but may include:

- Loss of suitable spawning habitat
- Environmental contaminants
- Predation on larval lake trout by alewife
- Thiamine deficiency from a diet of alewife
- Loss of genetically distinct strains

Photograph courtesy of the Canadian Department of Fisheries and Oceans

began in the mid-1800s when large numbers of people began to settle and develop the region. Multiple stressors continue to negatively impact the open lake ecosystem. The status of this ecosystem is changing and is heavily dependent on human management through predator fish stocking and control of exotic species such as the sea lamprey and zebra mussel.

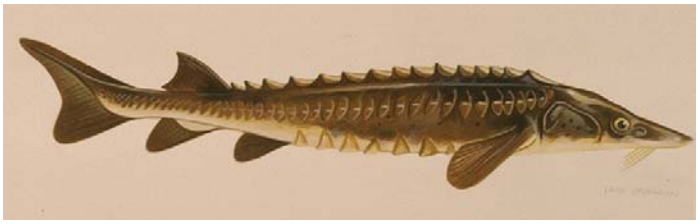
Fish communities represent the highest trophic levels within the Lake Michigan aquatic ecosystem. They are also the most visible indicators of ecosystem health and to most people, they represent one of the most important resources of the lake. Originally, Coregonids (including lake whitefish, lake herring, chubs, and ciscoes) dominated the fish communities, successfully inhabiting the many niches within the lake. Following the introduction of the sea lamprey in the 1950s, the population of top predator fish (such as lake trout and burbot) were decimated, and exotic species such as the alewife and rainbow smelt flourished. The alteration of fish communities has been the most obvious impairment to the aquatic ecosystem of Lake Michigan.

The plankton communities (microscopic plant and animals) of Lake Michigan are the foundation of the food web and therefore are one of the most critical components of the lake's ecosystem. Changes to these communities may be occurring as a result of the presence of contaminants and nutrients in the water and sediment as well as exotic species such as the spiny water flea (Bythotrephes cederstroemi) and the zebra mussel (Dreissena polymorpha).

The abundance and types of phytoplankton are highly variable within the lake, depending on the time of year, area of the lake, and availability of phosphorus and other nutrients. They are generally found throughout the open lake waters to the depths of light penetration. The increase in loading phosphorus in the lake has resulted in important man-induced change to phytoplankton communities, especially in nearshore areas. In addition, studies indicate that increased salinity and other environmental changes in Lake Michigan are enabling nonindigenous animals and algae to adapt more readily to the Great Lakes environment.

Bringing Back the Lake Sturgeon

Once abundant in the shallows of the Great Lakes, the Lake Sturgeon was overfished to the point of elimination in the Great Lakes. Total catch of lake sturgeon peaked in the mid 1880s at 4,901 metric tons (8.6 million pounds). However, by 1900 commercial catches began to decline quickly as the population of sturgeon plummeted. Between 1900 and the 1970s, sturgeon populations continued to decline. In addition to over-harvesting, habitat loss is a major factor contributing to the sturgeon's decline. In the Great Lakes, the damming of tributary waters has prevented access to historical spawning grounds and other spawning areas have been destroyed by siltation resulting from deforestation, poor agricultural practices and dredging. Pollution from nutrients and contaminants in the water has hindered reproductive success and the sturgeon's late maturity and infrequent spawning has also contributed to its decline.



Photograph courtesy of the Canadian Department of Fisheries and Oceans

Lake sturgeon populations that remain in the Great Lakes today represent only a fraction of their former number. The lake sturgeon is listed as a threatened species in 19 of the 20 states it inhabits and is recognized by the American Fisheries Society as threatened throughout North America. Lake sturgeon are now protected in most waters of the Great Lakes with closed seasons, size limits, harvest quotas and gear restrictions.

Throughout the Great Lakes, over 40 partnerships have been formed between federal and state agencies, tribal governments, Canadian agencies, academic institutions, commercial fishers, sport anglers, private organizations and individuals in order to conserve, protect and enhance lake sturgeon populations. U.S. Fish & Wildlife Service offices throughout the Great Lakes are working together with other partners to better understand the lake sturgeon's unique life history and meet rehabilitation challenges.

Zooplankton communities include many different invertebrates and comprise the bulk of the planktivorous fish diet. Because most zooplankton feed on phytoplankton, their abundance and geographic occurrence are similarly dependent upon water temperature, seasonal changes, and food availability. Zooplankton colonize open waters from the surface to the lakebed. Research conducted in the past 15 years indicates that zooplankton populations such as Daphnia, may be experiencing changes induced by Bythotrephes, an exotic species.

In addition, zebra mussels appear to be having a significant impact on benthic (bottom-dwelling) community structures and plankton abundance. Zebra mussels, which can attach themselves to any hard surface in the lake, have reached densities higher than 16,000/m2 in southern Lake Michigan. Negative impacts of their presence include increased food competition (at the expense of fish fry) for nearshore fish species (such as yellow perch), increased biomagnification of contaminants in fish eaters feeding on organisms that eat benthic organisms, and possible zebra mussel-induced mycrocystis blooms, which affect taste and odor in the water.

Coastal and Inland Wetland Systems

The coastal wetland system supports the greatest biological diversity and productivity in the Lake Michigan basin. Coastal wetlands are classified as open shoreline; unrestricted bays; shallow, sloping beach; restricted riverine; lake-connected inland; and protected or barrier beach. These wetlands are important because they collect nutrients and organic materials that are washed off the land into tributaries. These wetlands support both the aquatic food web and habitats for birds (resident and migratory), mammals, reptiles, amphibians, fish, and invertebrates, all of which depend on coastal wetlands for at least one life stage. Both lake

Status of Perch

A large decline in the number of yellow perch surviving their first year of life (young-of-the-year or YOY) has caused a reduction in the number of perch in Lake Michigan with serious effects on the sport fishing industry. The number of YOY perch captured lakewide has dropped dramatically since 1988. In addition, the number of yellow perch larvae captured at one site in Illinois has severely declined since 1994. Data from one site, however, cannot be used to decide what has happened lakewide. Therefore, WDNR along with other agencies and scientists has used a variety of assessments to analyze the status of the current yellow perch population. These assessments have focused on (1) egg deposition, (2) spawning, (3) post-larval perch, (4) YOY perch, and (5) winter-graded mesh gill net assessment Although more information is needed, these studies may indicate some recent recovery in the yellow perch population:

- The number of yellow perch egg masses found in spawning areas in the lake increased from 0.5 per 1,000 square meters (m2) searched in 1997 to 7.29 per 1,000 m2 searched in 2001.
- In 1998, a total of 4,512 yellow perch were captured during a spawning assessment, of which only 221 or 4.9 percent were females. In 2001, a total of 1,431 yellow perch were captured; 993 were males, and 438 (31 percent) were females.

For more information, see *www.dnr.state.wi.us/org/water/fhp/fish/lakemich/YELLOWPERCH.htm*

Photograph courtesy of the Canadian Department of Fisheries and Oceans

level fluctuations and longshore sediment transport are important in maintaining this highly productive system.

Coastal wetlands differ from inland wetlands in that they are shaped by lake processes such as waves, wind tides, and water level fluctuations. These processes result in constant shifting of the wetland communities, permitting hardy species able to accommodate such conditions to thrive while eliminating other species that would thrive under stable conditions. Multiple stressors continue to degrade the Lake Michigan coastal wetland system. Nonindigenous species, such as purple loosestrife, are still largely uncontrolled despite attempts to eradicate them. Changes in sediment composition and deposition have affected the habitat types, productivity, and diversity of these wetlands. The pace of shoreline modification is increasing, and there are no coordinated stewardship activities to protect or restore the remaining fragments.

The inland wetland system—wetlands away from the Lake Michigan shoreline—is a reservoir for water in the Lake Michigan drainage basin. There are many types of inland wetlands, including fens, bogs, wet meadows, and wet forests. The health of inland wetlands depends on the quantity and quality of groundwater and surface water present. Inland wetlands help to regulate the basin's volume of water as well as sediment and certain pollutant loads. They also store nutrients and serve as the nutrient exchange vehicle for the diverse species that use inland wetlands as habitat and feeding areas. Both wetland and upland species breed and feed in the Lake Michigan basin's inland wetlands.

Changes in Wetland Regulation: Impact of the Supreme Court Ruling

In January 2001, the U.S. Supreme Court narrowed federal authority to protect certain types of wetlands. The court's five-to-four decision narrowed the U.S. Army Corps of Engineers (USACE) regulating authority for wetlands not associated with waters of the United States such as a lake, stream, or river.

The court's decision came in response to a landfill battle in northern Illinois. The regional solid waste disposal authority sought to fill a wetland

Northwest Indiana Advance Identification of Wetlands Study

The Northwest Indiana Advance Identification of Wetlands study (ADID) produced maps and assessments of wetlands within the Lake Michigan Basin of Lake, Porter, and LaPorte Counties. The maps, which have a variety of corresponding biological, hydrologic, and management analysis, are available on the Indiana Geological Survey web site at http://adamite.igs.indiana.edu/arcims/lrim/start.html. This GIS site covering Lake, Porter and LaPorte Counties has interactive mapping capacity where users create customized maps. Besides wetlands, other natural features such as geology, soils, and hydrologic boundaries can be mapped with a variety of man-made features such as city boundaries, slag fill, and Superfund sites. Besides the ADID maps, the site includes the National Wetlands Inventory (US Fish and Wildlife Service) which is more comprehensive than the ADID but is outdated and provides less information.

The ADID study, completed in 2000, used rapid-assessment methodologies in the field combined with aerial photo, and topographic map, and file data analysis. Hard copy maps are available at these places: Lake County and Porter County Surveyor's Offices, Northwest Indiana Regional Planning Commission, LaPorte County Planner's Office, and the South Bend Field Office of the U.S. Army Corps of Engineers.

The wetland maps were produced under a partnership of local business, government, and environmental groups, lead by USEPA and the Northwest Indiana Regional Planning Commission. The purpose of the project was to identify and further the protection of wetlands having high quality plant and animal habitat, and wetlands that are critical to storm water storage and pollutant removal, in advance of development threats.

Wetland within Indiana Dunes National Lakeshore
Photograph by David Riecks, Illinois-Indiana Sea Grant*

for its new landfill. The wetland in question was actually created when an abandoned quarry filled with water and over time, the new wetland became a nesting spot for migratory waterfowl. The landfill proponents were able to successfully argue that USACE lacked regulatory authority to prohibit creation of the new landfill because the wetland was not linked to waters of the United States. The court ruled that the USACE must provide a nexus other than solely migratory bird stopovers.

The ruling now places the responsibility for protecting certain isolated wetlands in the hands of state and local authorities. Two examples of this change in state and local roles are found in Wisconsin and in Antrim County, Michigan (see box below).

Wetland Loss in the Lake Michigan Basin

Millions of acres of inland wetlands have been lost in the Lake Michigan basin to agriculture, industry, and urban development. Over the last two centuries, wetland losses in the four states at least partially within the Lake Michigan basin have been disproportionately greater than in many other U.S. regions. Since the 1780s, Lake Michigan basin states have lost an estimated 21.9 million acres (62.9 percent) of their wetlands out of the original 34.8 million wetland acres. This compares with an average loss of 52.8 percent nationwide. An estimated 12.9 million acres of wetlands remains in the four states, representing more than 12.3 percent of the wetlands within the lower 48 states.

Coastal Shore System

The Lake Michigan coastal shore system includes sand dunes, sand beaches, sand spits, bluffs,

bedrock and cobble beaches, alvars, and islands. These features buffer coastal wetlands and inland ecosystems from Lake Michigan waves, wind, and ice. These habitats are rich in species diversity but are greatly affected by natural processes such as weather, erosion, and lake level fluctuations.

Sand Dunes with Vegetation
Photograph courtesy of the National Park Service Indiana Dunes National Lakeshore*

Sand Dunes

Massive coastal sand dunes flank the Lake Michigan shoreline from northern Indiana continuing northeasterly through Michigan. Ancient high lake levels formed the beach ridges, and as the lake receded, the prevailing onshore winds continued to blow beach sand up the slopes. Lake Michigan is now home to the largest collection of freshwater sand dunes in the world. They run along the entire shore to heights of 300 feet and widths of more than 1 mile; they are interrupted only by river valleys, cities, and roads. The Lake Michigan dunes are numerous, diverse, and irreplaceable.

The dune system is composed of successive ridges of dunes: foredunes, interdunal areas, and backdunes (usually several). Dune and swale or ridge and swale community complexes are found at several locations throughout the Lake Michigan basin. In the south, the dunes or ridges run parallel to the Lake Michigan shore and are rich in oak savanna species. The wet swales

Keystone Species in Lake Michigan Food Web Vanishing

Diporeia spp.
(NOAA, GLERL)

One of the foundations of the Lake Michigan food web is disappearing. Diporeia spp., also known as scuds, sideswimmers, beach hoppers, and sand fleas, belong to the group of invertebrates called amphipods and are about 0.5 inch long. Diporeia have inhabited Lake Michigan since the Great Lakes were formed 5,000 to 10,000 years ago, and they are environmentally sensitive, thriving only in clean, cold, well-oxygenated water. Diporeia are eaten by a variety of Great Lakes fish and provide an important energy source because they contain high amounts of fat.

Populations of Diporeia in the Great Lakes are important indicators of environmental and ecological health, and this is why it is particularly alarming to find that they have disappeared from vast areas of the bottom of Lake Michigan. While scientists have not yet determined the exact cause of the disappearance of the amphipods, they suspect it is linked to the introduction of zebra mussels in Lake Michigan in 1989, severely limiting the food available to Diporeia.

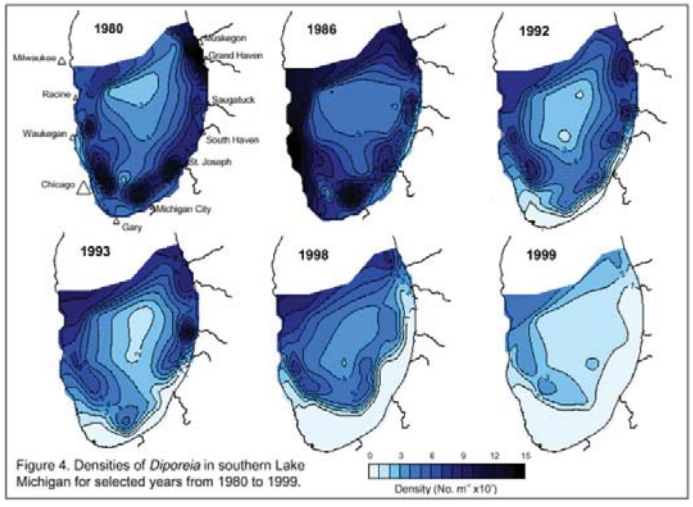


Figure 4. Densities of *Diporeia* in southern Lake Michigan for selected years from 1980 to 1999.

Lake Michigan Federation Biodiversity Recovery Report

The Lake Michigan Federation released a publication in 2001 entitled, The Lake Michigan Biodiversity Recovery Support Document compiled from research, presentations, and discussions surrounding the Urban Aquatic Habitat Summit held in November 2000. The purpose of this report was to gather relevant information for a biodiversity blueprint for Lake Michigan's shoreline and tributaries.

The nearshore Lake Michigan zone is among the most biologically productive in the region. Nearly 30 percent of the globally significant species and communities within the Great Lakes basin are associated with coastal shore systems. At the same time, the lakefront of the area studied (from the Indiana Dunes to the Illinois State Park) is under enormous pressure to produce a strong quality of life for the region.

The report's finding included:

(1) The Illinois - Indiana Lake Michigan shoreline is vastly different from its presettlement state. Most coastal wetlands and nearshore aquatic habitats have been eliminated or degraded. The effect of natural forces on sand transport and shoreline development has been greatly reduced or eliminated entirely in some areas.

(2) Fish populations have changed dramatically since settlement. Original keystone predator species have been replaced with stocked species. Native species are subject to extreme stresses as a result of exotic species invasions.

(3) Lake Michigan's fisheries represent a strong potential economic, recreational, and environmental benefit for the Illinois - Indiana area. Significant work is required to develop healthy, sustainable populations of fish species in degraded habitats, including mitigating human impacts and preventing further exotic species invasion. Federal policy tools may prove most helpful in achieving these ends.

(4) Former and working industrial sites in the Chicago area are beginning to serve as habitats for viable fish and bird populations, suggesting that conditions are favorable for urban habitat recovery.

(5) It is essential to preserve rare habitats that cannot feasibly be replaced, such as the dune and swale systems of northwestern Indiana. Stresses to these habitats should be minimized as much as possible.

(6) The Chicago shoreline serves as habitat for a variety of fish species. As the city redevelops its shoreline over the next several years, it has a unique opportunity to emphasize aquatic habitat construction as part of the lakefront park planning process.

(7) Multiple options for continued large- and small-scale habitat restoration and creation exist in the Chicago area. Primary needs include funding and research from government and academic bodies

For more information, visit *www.lakemichigan.org/habitat/bio_recovery.asp*

between these ridges support rich prairies and sometimes rare coastal plain marsh communities. In the north, the ridges are typically dominated by red and white pine and other conifers, and the swales by white cedar swamps or sedge meadows. Sand dunes around Lake Michigan are threatened by residential development, often very close to the shore, and by mining. On the eastern shore of Lake Michigan, an invasive, nonindigenous species, Baby's breath, is threatening dune ecosystems. "Blowouts," which occur most frequently in the foredune area, are created when the vegetation is disrupted and the wind quickly erodes the sand, leaving a saucer-shaped depression. The most serious blowouts occur as a result of human activity.

Sand Beaches

Sand beaches are a prominent coastal Lake Michigan feature. They may be erosional, transitory, or depositional. Shoals, sandbars, and sand spits protect lagoons and coastal marshes from wind and wave action. Artificial shoreline structures and hardening of the shoreline have interrupted the longshore sediment transport that naturally erodes and replenishes sand beaches. In many areas, tons of sand are brought in each year to artificially replenish

Lake Michigan Beach, Leland Michigan
Photograph courtesy of Michigan Travel Bureau*

beaches for recreational purposes. Beach closure problems caused by excessive levels of pathogens are discussed in Section 4.

Tributary System

Tributary streams and rivers are connected to Lake Michigan in several ways. Energy and material are transferred from lake to tributary and tributary to lake by means of fish movement upstream and downstream and by waters carrying material and nutrients downstream. Diverse plant and animal habitats are found throughout the tributary system, and many of these habitats accommodate Lake Michigan fish. The range of tributary habitats present depends on the size, slope, substrate, and geology of the drainage basin; basin land use; groundwater characteristics; the climate; and the nature of the terrestrial vegetation. The connection of the streams and rivers to the lake maximizes the biodiversity and production of fish in the lake.

The quality of many tributary rivers in the Lake Michigan basin has been significantly impaired by channelization, dredging, damming, sedimentation, bankside vegetation loss, eutrophication, increased spring flooding, and toxic contamination. Large areas of inland forests and wetlands that once served to regulate the quantity and quality of water flowing into tributaries have been lost. As a result, tributaries carry increased pollutant and sediment loads to the lakes, and the suitability of those tributaries as fish spawning habitats has been seriously impaired. Habitat degradation has been the most severe in urban areas. Pollution from agriculture, industry, and urban development has contaminated rivers and sediment as well as the fish and wildlife that depend on those rivers. Many rivers, particularly at the rivermouths, have been declared AOCs and many of their beneficial uses have been impaired.

Although the public uses many Lake Michigan basin rivers and streams, the uses are not necessarily sustainable at this time. Progress is being made in improving and protecting tributary rivers and streams, largely through the efforts of watershed groups and remedial actions at AOCs. For information on Lake Michigan tributaries, Surf Your Watershed at *www.epa.gov/surf*

Lake Michigan Dunes May Be Younger than Previously Thought

Lake Michigan sand dunes were once thought to have been formed over 5,000 years ago and to have remained relatively static ever since. New research has found that wind, waves, and human activity have reshaped the dunes since the glaciers retreated at the end of the last ice age, and the dunes continue to change today. Alan Arbogast of Michigan State University determined the age of the dunes by dating the layers of decomposed plant residue within them. His research revealed that dunes appear to grow in spurts over many years. These spurts are separated by hundreds of years of dormant growth.

Arbogast's work has helped regulators and planners understand that the dunes are active and that shifts in the sands are not entirely the result of human activities. However, the research also reveals that construction on or near the dunes may be destabilized as the dune sands continue to move, because the formation process is ongoing.

Source: Chicago Tribune, November 18, 2001