Lake Michigan: State of the Lake '99
Abstracts

A Conference Convened by the Grand Valley State University
Robert B. Annis Water Resources Institute
November 8-9, 1999

Plenary Session:
Theme: **Planning for Lake Michigan**

Lake Michigan Lakewide Management Plan
Judy Beck, U.S. Environmental Protection Agency

The Lake Michigan Lakewide Management Plan (LaMP) is scheduled for release on Earth Day 2000. The LaMP is an element of the Great Lakes Water Quality Agreement between the United States and Canada. The plan will describe the status of the Lake Michigan ecosystem, identify environmental problems and sources of those problems, and propose suggested actions and milestones for implementation. The document will also reflect a broader ecosystem management approach. In addition, human health information will be integrated into the document. The document will identify a series of goals and subgoals that are intended to guide the development of Lake Michigan programs.

Specific sections of the document will include:

- General overview of purpose, vision, goals, and objectives of the LaMP
- A description of the present status of the Lake Michigan ecosystem
- A proposed set of indicators that will form the basis for a monitoring system for ongoing assessment of health of the ecosystem
- An identification of the causes, sources, and pathways for the specific pollutants and stressors in the Lake Michigan ecosystem
- A strategic action agenda for addressing issues of concern affecting the ecosystem

The LaMP process is collaborative and requires the cooperation of multiple jurisdictions and stakeholders around the basin to accomplish the goals. Problems will be prioritized based on scientific studies that are currently underway in the basin such as the Lake Michigan Mass Balance study. The Lake Michigan Forum, a multi-stakeholder group,

provides input to the LaMP as well as the Technical Coordinating Committee of the states and agencies. A Management Committee oversees the process.

Strategic Plan for Management of Great Lakes Fisheries
Tom Trudeau, Great Lakes Fishery Commission

In general, terrestrial ecosystems can be described by their vegetation types, and aquatic ecosystems by the structure of their fish communities. The historic, Lake Michigan fishery was based on a fish community structure consisting of lake whitefish, lake herring, and six species of ciscoes with lake trout and burbot as the top predators. Of the top predators lake trout were the more abundant species.

European settlement of the Great Lakes basin resulted in significant changes to its fisheries through the effects of pollution, over harvest, and from engineering projects that opened the Great Lakes waterways to oceanic shipping. Construction of the Erie and Welland Canals first provided a pathway for exotic species, such as sea lamprey and alewives, to enter the Great Lakes basin and then to become established in all the waterways of the Great Lakes. Sea lampreys decimated lake trout populations to a point where they became extinct in some lakes, such as Lake Michigan. In the absence of a top predator, alewives became the dominant fish species in the Lake Michigan ecosystem, and by the mid-1960's comprised an estimated 85% to 90% of the Lake Michigan fish biomass.

In response to declining fish stocks Canada and the United States established by Convention the Great Lakes Fishery Commission. The GLFC was given the dual responsibilities of establishing a sea lamprey control program and to facilitate research and management activities pertaining to the productivity of fish stocks of common concern.

Establishment of an effective sea lamprey control program permitted the re-introduction of lake trout beginning in the mid-1960's. Coho and chinook salmon, non-native species, also were introduced during this time period because they were perceived to be more efficient predators of alewives. The trout and salmon stocking program has contributed to a significant reduction in alewife abundance which has allowed for a resurgence of native species such lake whitefish, bloater chubs, lake herring, burbot, and yellow perch. The Lake Michigan fishery has evolved from a relatively simple fishery dominated by alewives to a diverse fishery with complex species interactions. This has lead to a recognition that to effectively manage this fishery will require a cooperative and coordinated effort by all management agencies on a lakewide basis not only for Lake Michigan but for all of the Great Lakes.

In 1980 federal, state, provincial, and tribal resource agencies agreed to manage the Great Lakes fisheries through the Joint Strategic Plan for Management of the Great Lakes Fisheries. The GLFC provided a neutral forum for management agencies to

achieve a consensus on fishery management strategies. Each Lake Committee was charged with the responsibility of developing a set of fish community objectives for their lake and to routinely provide progress reports on achievement of these objectives. The Lake Michigan Fish Community Objectives were published in 1995. These objectives were an attempt to achieve some semblance of biological integrity for the mix of non-native and native species comprising the Lake Michigan fish community. The ultimate goal is to achieve a functional and productive Lake Michigan ecosystem.

Lake Michigan Hydrologic and Economic Issues

Roger Gauthier, U.S. Army Corps of Engineers

Although most coastal communities along Lake Michigan can date their initial development back to the early 1800s, significant capital investment in shore property has occurred during the past 30-50 years. Lake Michigan water levels have fluctuated broadly since they were first measured in the 1820s. A critical need exists to anticipate the economic consequences of major shifts in water levels, including global warming implications.

The U.S. Army Corps of Engineers and key cooperators, including state, county and academic representatives from Michigan, have initiated a study on the potential damages to Great Lakes shorelines over the next 50 years. A detailed site study of the Berrien County shoreline conducted in 1992 indicated that erosion-related losses could reach $250 million in the county over the next 50 years.

The prime objective of these studies is to create computer models capable of estimating economic, social, environmental, and cultural impacts under various hydrologic scenarios. These studies rely on geographic information systems (GIS) datasets containing detailed information on hazard zones and affected properties.

Integrated Water Resource Management

Dr. Jeffery A. Foran, UWS/UWM Great Lakes Water Institute

Water resource management can no longer be conducted simply at the level of Lake Michigan or the Great Lakes. Rather, it must consider a variety of technical and non-technical issues at the local, regional, national, and global levels. Integrated water resource management must begin with a strong scientific and technical basis, addressing stressors of both natural and anthropogenic origin. For example, no longer can the effects of individual or even groups of chemicals on aquatic biota be managed without considering the concurrent influence of a variety of other stressors (e.g., habitat alteration, disease, climate change) on those biota. But water resource management must move even beyond simple reliance of information provided by the “hard” sciences, to an integrated approach that draws on and considers engineering, economics, the social sciences, business, and art and architecture.

Our management of our freshwater resources will require new knowledge, partnerships, and approaches. It will also require that we look beyond watershed, media, and other boundaries created by governments, academic departments, and other institutions; and that we draw on integrated approaches that ensure the sustainability of Lake Michigan and the Great Lakes in the context of global freshwater resource management.

Breakout Session 1
Theme: **Lake Michigan Mass Balance Study**

Lake Michigan Mass Balance Study

Paul Horvatin, Great Lakes National Program Office
Glenn Warren, U.S. Environmental Protection Agency
Louis Blume, U.S. Environmental Protection Agency
Robert Day, Michigan Department of Environmental Quality
Melissa Hulting, ECO
Brian Eadie, NOAA/GLERL
Paul Bertram, NOAA/GLERL
Charles Madenjian, NBS, U.S. Geological Survey
Russ Kries, U.S. Environmental Protection Agency

The Lake Michigan Mass Balance Study is designed to answer questions that will allow environmental managers to make well informed decisions on actions which will reduce toxic pollutants in Lake Michigan. Mass Balance is a simple concept based on the law of conservation of mass: we should be able to balance the amount of pollutant entering a lake (the load) with that leaving, trapped in the lake, or changed chemically. The monitoring of loads from rivers and the atmosphere, and resuspension of sediments will allow us to determine the importance of each of those paths to the total amount of a pollutant entering the lake water. Measurements of contaminants in the food web allow us to see how they bioaccumulate. The information gathered during the Mass Balance Study is being used in a mathematical model of the Lake Michigan ecosystem. This model will allow scientists and environmental managers to determine what effects reduction in pollutant load will have on the lake, and in particular, on top predator (lake trout and coho salmon) fish tissue contaminant levels. The model is based on one developed for and earlier study in Green Bay, and is designed to provide long range predictions on the effects of pollutant reductions or increases.

Many scientists at multiple universities and other agencies are working on the Lake Michigan Mass Balance Study. Their work will be published primarily in scientific papers. Details on the Lake Michigan Mass Balance Study can be found on the following Web site: (http://www.epa.gov/glnpo/lmmb/index.html).

Breakout Session 2
Theme: **Exotics and Great Lakes Information**

Alien Invaders of the Great Lakes – Impacts and Implications for Fishery Resources
Chuck Pistis and Dr. Ron Kinnunen, Michigan Sea Grant.

This session will provide an overview of exotic invasions of the Great Lakes with an emphasis on past, present, and future impacts on Great Lakes Fishery Resources.

Impacts of sea lamprey, alewife, zebra mussels, spiny water flea, gobies, Eurasian ruffe, Eurasian milfoil, purple loosestrife, and bluegreen algae will be presented.

Availability and Use of U.S. Geological Survey Streamflow Data on the Internet—Lake Michigan Basin
Steve Blumer, U.S. Geological Survey

The U.S. Geological Survey is the Nation's largest earth-science agency and has the principle responsibility with the Federal Government for providing hydrologic information and for appraising the nation's water resources. In the 45,600 square mile Lake Michigan drainage basin, the USGS, Water Resources Division currently operates more than 100 real-time stream gaging stations. These stations are distributed throughout all of the major tributary watersheds. When stations that were formerly operated are included, the coverage included most streams. This monitoring provides a significant streamflow database for recreationists, facilities managers, regulators, and groups concerned about the overall Lake Michigan watershed and individual tributary watersheds.

The purpose for each stream gage varies; however, numerous uses can be made with the data beyond the original intent for the station. All USGS stream gaging data are stored in computerized databases. Although the raw streamflow data are extremely valuable as stand alone information, database retrievals provide equally useful summaries of the data. The following statistical packages are discussed in relation to Lake Michigan stream gaging stations: flood frequency analysis of annual peak flow data, flow duration tabulation, monthly and annual streamflow summaries, low-flow statistics such as the 7Q10, state-discharge ratings, and graphs of historical streamflow.

The Great Lakes CD-ROM

Monica Rogers, Center for Environmental Study at Grand Rapids Community College.

What is “green” and round and played all over? If the Grand Rapids, Michigan, -based Center for Environmental Study has its way, the answer will be its new educational CD-ROM game, *The Great Lakes*. The program, targeted for children grades 3-8, uses a game format to teach kids about the ecology, history, economy and other aspects of the Great Lakes.

Starting in the future, players are brought back to the present to find out what happened to the Great Lakes ecosystem. During their journey, they learn how decisions made today affect the Great Lakes for centuries to come. At the end, players are challenged to apply their understanding to issues that are as current as today’s newscasts.

The Great Lakes is the first in the **Caring for Planet Earth** series of interactive, multimedia CD-ROMs. The second program, *Tropical Forests*, is currently in preparation. Each title in the series is based on the best available scientific information and each will emphasize the theme of sustainable living for the future. The CD includes a glossary, the Great Lakes Resource Guide for educators and contact information for the Great Lakes region environmental and governmental organizations.

Breakout Session 3
Theme: **Policy and Planning for Lake Michigan** –
Stakeholder Communication and Cooperation

Lake Michigan Forum
Dr. Janet Vail, GVSU-WRI, Co-Chair
Dr. Ron Baba, University of Wisconsin, Co-Chair

This session will be devoted to the quarterly meeting of the U.S. Environmental Protection Agency Lake Michigan Forum. The Forum was organized to provide input from broad interests around Lake Michigan for the development of the Lake Michigan Lakewide Management Plan (LaMP). It is a diverse stakeholder group from academia, government, tribes, business, industry, organizations, fisheries, agriculture, and others. Its members meet on a quarterly basis around the Lake Michigan Basin.

Topics for the session include updates on the LaMP progress and Lake Michigan Forum Projects. Initiatives of the Forum have included the Primary Metal Project, and agricultural stewardship effort, and the Making Lake Michigan Great Tour of the W.G. Jackson research and education vessel from the Grand Valley State University Robert B. Annis Water Resources Institute. The Jackson visited 12 ports of call in 1999 to spread the word about lakewide planning and to receive input from basin stakeholders on their Lake Michigan issues.

The Lake Michigan Forum will be seeking input from conference attendees and speakers for lakewide planning. Especially important is whether the LaMP vision and goals match the expectations of all stakeholders. The Lake Michigan LaMP vision statement is a sustainable Lake Michigan ecosystem that ensures environmental integrity that supports and is supported by economically-viable, healthy human communities. The LaMP goal is to restore and protect the integrity of the Lake Michigan ecosystem through partnerships. The endpoint subgoals are:

1. We can all eat any fish
2. We call all drink the water
3. We can all swim in the water
4. All habitats are healthy, naturally diverse and sufficient to sustain viable biological communities
5. Public access to open space, shoreline and natural areas is abundant and provides enhanced opportunities for human interaction with the Lake Michigan ecosystem.
6. Land use, recreation and economic activities support a healthy ecosystem.

The means to the subgoals are:

1. Sediments, air, land and water are not sources or pathways of contamination that affect the integrity of the ecosystem.
2. Exotic species are controlled and managed.
3. Ecosystem stewardship activities are common and undertaken by public organizations in communities around the basin.
4. Collaborative ecosystem management is the basis for decision-making in the Lake Michigan basin.
5. We have enough information/data/understanding to inform the decision-making process.

Breakout Session 4
Theme: **Lake Michigan Research**

Spatial Patterns in PCB Concentrations of Lake Michigan Lake Trout: Importance of Prey Fish Population Dynamics

Dr. Charles P. Madenjian, United States Geological Survey, Biological Resources Division, Great Lakes Science Center

Guy W. Fleischer, Leslie M. TeWinkel, Timothy J. DeSorcie, and Jeffrey D. Holuszko, United States Geological Survey, Biological Resources Division, Great Lakes Science Center

Most of the PCB body burden in lake trout (*Salvelinus namaycush*) of the Great Lakes is from their food. Monitoring PCB concentration in lake trout has been instrumental in developing consumption advisories and for determining the effectiveness of management actions to reduce PCB contamination in the environment.

We determined PCB concentrations in lake trout from three different locations in Lake Michigan during 1994-1995, and we analyzed lake trout diets at all three locations. We also determined the PCB concentrations in alewife (*Alosa pseudoharengus*), rainbow smelt (*Osmerus mordax*), bloater (*Coregonus hoyi*), slimy sculpin (*Cottus cognatus*), and deepwater sculpin (*Myoxocephalus thompsoni*), five species of prey fish eaten by lake trout in Lake Michigan, at three near shore sites in the lake. Despite the lack of significant differences in the PCB concentrations of alewife, rainbow smelt, bloater, slimy sculpin, and deepwater sculpin from the southeastern nearshore site near Saugatuck (Michigan) compared with the corresponding PCB concentrations from the northwestern nearshore site near Sturgeon Bay (Wisconsin), PCB concentrations in lake trout at Saugatuck were significantly higher than those at Sturgeon Bay. The difference in the lake trout PCB concentrations between Saugatuck and Sturgeon Bay could be explained by diet differences.

The diet of lake trout at Saugatuck was more concentrated in PCBs than the diet of Sturgeon Bay lake trout, and therefore lake trout at Saugatuck were more contaminated in PCBs than Sturgeon Bay lake trout. Our findings were useful in interpreting the long-term monitoring series for contaminants in lake trout at both Saugatuck and the Wisconsin side of the lake. Understanding the prey fish population dynamics in Lake Michigan was of critical importance in interpreting the long-term trends for contaminant concentrations in Lake Michigan lake trout.

The Potential Impacts of Climate Change on Lake Michigan Water Resources

Dr. Frank H. Quinn, NOAA/GLERL

There is a likely potential for significant global climate change due to increased greenhouse gas concentrations in the atmosphere. The impacts of this change, when translated to the Lake Michigan basin, is significant in terms of water resources and lake levels. Because of the relatively small variability of lake levels, about 1.8 m, significant uses have become dependant upon small changes in water levels and outflows, resulting in system sensitivity to relatively small changes in climate variability and change. Studies conducted in the U.S. and Canada since the early 1980's show an increased possibility of hydrologic changes due to global warming, resulting in major changes to the water resources and lake levels.

A series of climate change scenarios have been developed for the Great Lakes basin using General Circulation Models (GCMs), climate spatial transposition, and historical climate analogues. The impacts of climate change on the Lake Michigan water resources occur through higher air and water temperatures, both positive and negative changes in precipitation, decreases in runoff, less snowfall and snowpack accumulation, higher evapotranspiration and higher lake evaporation. The integrated effects of these impacts are a major reduction in lake levels (1-2.5 meters) and tributary flows (10-40 percent). This paper provides a review of Lake Michigan impacts, including research currently in process for the U.S. National Assessment.

Bathymetry of Lake Michigan
Dr. David Reid, NOAA-GLERL, Peter Vincent, NOAA/GLERL

Bathymetry is the science of measuring and mapping the depths of oceans, seas, lakes, etc., to delineate the topography of their basins. Bathymetric maps are two-dimensional representations of the 3-dimensional representations of the three-dimensional shape of these basins. NOAA/GLERL stared a project in 1994 to utilize and develop the existing Great Lakes soundings data holdings of the United States and Canada into useful and publishable bathymetric maps and digital data files, and related scientific manuscripts.

Lake Michigan was the first lake for which new bathymetry was completed. Contour resolution of the resulting digital database is five meters. Two map views are presented: an 84" high three-section full color map at full five meter resolution, and a standard poster-sized full color map at ten meter contour resolution. Besides these maps, a poster explaining the project and discussing the Lake Michigan bathymetry, plus a computer-based interactive CD-ROM of the Lake Michigan bathymetry images, will be part of the display.

Tumors in Lake Michigan Zooplankton and Their Consequences for Monitoring Programs
Henry A. Vanderploeg, NOAA/GLERL
M. Omair, CGLAS, University of Michigan

Bernard Naylor, Pathology Department, University of Michigan

Descriptions of the external appearance of large tumors have been reported in the scientific literature and popular media. These reports have generated much concern as to the tumors' cause, ecological consequences, and implications for human health. Observations so far suggest the tumors are possibly neoplastic. Over 40% of the zooplankton species in Lake Michigan have been observed with tumors. Frequency of occurrence ranged between 0 and 74% in different species. We suspect that occurrence of the tumors may be part of a global problem because such tumors have been observed in lakes in Europe. We will report progress on ongoing work describing spatial distribution, ecological characteristics of affected species and life stages, nature of the tumors, and speculate as to possible causes.

The only recent discovery of tumors in samples dating back to 1995 raises questions about the adequacy of plankton monitoring programs in Lake Michigan and other Great Lakes. We take the opportunity to describe what constitutes a proper plankton-monitoring program for tumors and food web changes.

Declines of the Amphipod *Diporeia spp*. in Lake Michigan: Extent, Potential Causes, and Consequences

Thomas F. Nalepa and David L. Fanslow, Great Lakes Environmental Research Laboratory, NOAA
Steven A. Pothoven Cooperative Institute for Limnology and Ecosystems Research, University of Michigan

We have been documenting densities of benthic macroinvertebrate populations in the southern portion of Lake Michigan since 1980. Samples have been taken at 40 sites in spring, summer, and fall in 1980-81, 1896-87, 1992-93, and 1998-99. Beginning in 1992, we noted that densities of the important amphipod *Diporeia spp*. began to decline at sites in the far southeastern portion of the lake. This organism is considered a keystone species in the Lake Michigan food web as it feeds on material settled to the bottom from overlying waters and, in turn, is fed upon by most species of fish. Continued sampling in 1998 and 1999 indicates that the area with reduced densities of *Diporeia* has expanded greatly. Densities have declined to zero at depths of at least 45 meters along the eastern shoreline as far north as Grand Haven, and along the western shoreline to Chicago. We suspect that the decline can be attributed to the introduction and rapid expansion of the zebra mussel. The filtering activity of this mussel intercepts food material before it settles to the bottom, leaving little food for *Diporeia*. Yet there are some inconsistencies with this hypothesis that seem to indicate that the connection is not all that simple, or that other possibilities exist. For example, lipid content of *Diporeia* increases as the population declines. Lipids are used for energy storage and should decline with a decrease in food. Fish species that normally feed heavily on *Diporeia* (i. e., bloater, whitefish, slimy sculpin, etc.) are now feeding more on *Mysis*. In other cases, these fish are no longer present in areas with no *Diporeia*.

Paleo Lake-level Fluctuations in Lake Michigan over the Past 4,700 Years

Dr. Todd Thompson, Indiana geological Survey, Indiana University
Dr. Steve Baedke, James Madison University

The internal architecture and timing of beach-ridge development in five strandplains bordering Lake Michigan were studied to understand the physical limits and timing of past lake-level fluctuations. Swash zone deposits were recovered from individual beach ridges to yield the elevation of the lake at the time of beach-ridge formation, and basal wetland sediments in the swales between ridges were radiocarbon dated to date the age of the beach ridges. These elevation and age data were used to create five relative lake-level curves that show long-term changes in water volume of the lake and differential isostatic rebound between sites. When the isostatic rebound is removed from the relative lake-level curves and the residual data sets are combined, the resultant graph shows the upper limit of the lake level observed at the Port Hurn outlet of Lakes Michigan and Huron during the past 4,700 calendar years.

The long-term behavior and fate of sediments and associated materials in Lake Michigan

Brian J. Eadie, John A. Robbins, Pat Van Hoof, and Tom Johengen, NOAA-Great Lakes Environmental Research Laboratory

One of the primary efforts at GLERL is to estimate the contribution of sediments to cycling, behavior, and fate of contaminants in aquatic systems. Sediments contain the vast majority of the inventory of many chemicals of concern, nutrients as well as contaminants. For example, over 80% of the inventories of phosphorus, mercury, and PCBs are stored in the sediments and we estimate that more of these compounds re-enter the water column via sediment-water exchange than all of the combined external inputs.

For more than a decade, GLERL scientists have been collecting samples and refining interpretations of the major processes regulating the behavior of this class of materials. During this time, sediment samples have been carefully collected at over one hundred sites, and sediment traps have collected materials settling out of the water column, providing rates for subsequent modeling efforts. Much of this flux occurs during the winter unstratified period when the lake intimately couples with the inventory of materials in the sediment mixed layer. Measuring the mass collected allows us to calculate the gross downward flux of particulate matter and associated constituents and to calculate settling velocities.

Target contaminant (PCB, Hg), and conventional (C,N,P,Si) parameters have been measured on all 0-1 cm sediment samples, on selected sediment cores and trap samples. Sediment accumulation rates have been calculated from the Pb-210 and Cs-

137 data measured on all box cores. The distribution of downcore integrated Cs-137 illustrate the heterogeneous nature of sediment accumulation in the lake over the past 50 years.

Surface sediment (0-1 cm) concentrations of total PCB concentrations are clearly highest in the southeastern portion of the main lake where maximum sediment accumulation rates also occur. Some of these materials are available for resuspension in intense winter-spring storms, a process that keeps materials in circulation for decades after their removal from production.

Great Lakes CoastWatch Program

George Leshkevich, NOAA/GLERL

CoastWatch is a nationwide National Oceanic and Atmospheric Administration (NOAA) program within which the Great Lakes Environmental Research Laboratory (GLERL) functions as the Great Lakes regional node. In this capacity, GLERL obtains, produces, and delivers environmental data and products for near real-time monitoring of the Great Lakes to support environmental science, decision making, and supporting research. This is achieved by providing Internet access to near real-time and retrospective satellite observations, in-situ Great Lakes data, and derived products via the CoastWatch Great Lakes web site (http://coastwatch.glerl.noaa.gov).

Great Lakes CoastWatch data are used in a variety of ways including monitoring of algal blooms, plumes, ice cover and water temperatures, two and three dimensional modeling of Great Lakes physical parameters such as wave height and currents, damage assessment modeling, research, and for educational and recreational activities.

Atmospheric Deposition of Toxics: Integration of Science and Policy

Timothy H. Brown, Delta Institute

Recent research on atmospheric deposition of toxics in the Great Lakes has shown that long-range transport and deposition of pollutants contribute significantly to the input of contaminants to the Great Lakes. Deposition can occur directly to the water surface, or indirectly to the land surface in the watershed which can then be carried with runoff to surface water bodies. Several atmospheric deposition studies have been conducted on Lake Michigan which show that addressing the issue will require regional, national, and international efforts. Due to the significant research conducted on Lake Michigan, there is an opportunity to consider Lake Michigan as a case study in integrating scientific research with policy tools to address atmospheric deposition issues. The Delta Institute will provide an overview of atmospheric deposition issues in the Lake Michigan basin and outline promising policy approaches.

Distribution of Heavy Metals in the Sediments of the Lower Grand River

Richard Rediske, Carissa Bertin, Michael Swiech, and John Gabroseck, Robert B. Annis Water Resources Institute Grand Valley State University

A preliminary investigation of the nature and extent of sediment contamination in the lower Grand River was performed. Localized areas of sediment contamination were found at the downstream tips of several meander core islands. These areas serve as sediment deposition zones and reflect historical discharges of heavy metals to the lower Grand River. High water events can readily transport contaminated sediments from these deposits and increase the loading of contaminants to Lake Michigan. Levels of heavy metals were found to exceed sediment quality guidelines at three locations.

The normalization of heavy metal data with aluminum and iron was examined to determine the extent of anthropogenic enrichment in the data set. Normalization techniques compensate for the natural variability of trace metals and facilitate the identification and quantification of the elemental fraction that was by anthropogenic sources. Statistically significant correlations between the normalization elements and selected metals (cadmium, chromium, copper, lead, nickel, and zinc) were obtained from a group of deep and middle core sections that were not influenced by anthropogenic sources. The concentration of heavy metals at a number of locations exceeded the 95% confidence limit of the background data set. Correlation coefficients (r^2) and regression lines for the normalized data were similar to relationships previously reported from NOAA and NS&T data sets of estuarine sediments.

Breakout Session 5
Theme: **Monitoring, Policy, and Restoration for Lake Michigan**

E. coli **Monitoring programs for Lake Michigan Beaches: Fact or Fiction?**

Dr. Richard L. Whitman and Meredith Becker Nevers, U.S. Geological Survey: Lake Michigan Ecological Research Station

Fecal coliform bacteria in public swimming waters indicate the potential presence of more harmful pathogens, and elevated concentrations can threaten visitors' health. Since 1984, the beaches along the southern shore of Lake Michigan have been monitored for fecal coliforms or *E. coli*. When density exceeds the state water quality criteria (400 CFU fecal coliforms per 100 ml; 235 CFU *Escherichia coli* per 100 ml water), the beaches are closed to visitors. In 1997, beaches along the northeastern shore of Lake Michigan at Sleeping Bear Dunes National Lakeshore were also monitored. The assay required for monitoring *E. coli* requires a 24-hour incubation, so results are not available until the day after a water sample is collected. Our analysis suggests that it is not possible to predict *E. coli* along the shore.

An experiment conducted on a smaller inland lake at Sleeping Bear Dunes National Lakeshore provided strong evidence for the combined influence of wind and rain. Preliminary research along the beaches has also revealed an abundance of bacteria in the wet subsurface sand. Sand along the shore in infiltrated by groundwater and lake water, and bacteria absorbed to silt particles are trapped in the sandy substrate. With the inadequacy of current monitoring techniques and the numerous poorly understood contributing variables, the development of an effective monitoring approach is critical for these popular swimming areas.

Assessing and Coordinating Monitoring Efforts in the Lake Michigan Basin

Matt Doss, Great Lakes Commission

Two efforts are underway to assess and coordinate monitoring efforts in the Lake Michigan Basin. The Lake Michigan Tributary Monitoring Project is assessing monitoring activities and data collection efforts in major tributaries to Lake Michigan. The goal of the project is to conduct a comprehensive review of monitoring programs at the federal, state and local levels for the targeted watersheds; analyze gaps, inconsistencies and unmet needs; assess the adequacy of existing efforts to support critical ecosystem indicators; and develop a plan for addressing major monitoring needs, particularly those considered most important for lakewide management decision making.

The Great Lakes Commission is coordinating the project on behalf of the U.S. Environmental Protection Agency (U.S. EPA), Region 5 Lake Michigan Team and is

collaborating with public advisory councils and related groups in the 10 Lake Michigan AOCs plus Grand Traverse Bay, St. Joseph River and Grand River, Michigan, and Door County, Wisconsin. Project results will be compiled and reported in early 2000.

The Lake Michigan Monitoring Coordination Council is being formed by various federal, state and local agencies to foster cooperation and coordination among groups involved in ecosystem monitoring activities in the Lake Michigan Basin. The Council's mission is to provide a forum for coordinating and supporting monitoring activities in the Lake Michigan basin and to develop and make broadly available a shared resource of information, based on documented standards and protocols, that is useable across agency and jurisdictional boundaries. The Council reflects and responds to similar initiatives underway at state and federal levels. The Lake Michigan Council is the first such entity to be based on an ecosystem rather than political boundaries. The Council will work in cooperation with the Lake Michigan Lakewide Management Plan in developing and periodically updating a monitoring plan for the Lake Michigan Basin. The Great Lakes Commission is providing secretariat support to the Council and is formally soliciting representation on the body. The first formal meeting was held on Sept. 22, 1999 in Milwaukee.

Atrazine Delivery to Lake Michigan from the St. Joseph River Watershed
Joe Ervin, Michigan State University, Institute of Water Research

Results from a project entitled "Atrazine Delivery to Lake Michigan from the St. Joseph River Watershed as Determined by Immunoassay and Minimal Sampling Effort" will be presented. Rainfall, surface and groundwater were monitored. This project was supported by the Great Lakes Protection Fund, 319, USGS, and Michigan State University.

Improving Water Quality Input Flow into Michigan's Great Lakes through GIS Technology
Jeremiah Asher and Ouvang Da, Michigan State University, Institute of Water Research

Geographic Information System (GIS) technology and non-point pollution monitoring are used to improve water quality input flow through determining areas with high erosion and nutrient loading potential. The graphic (mapped) output assists water managers in prioritizing efforts by focusing on high risk areas within the watershed.

Watershed-based Department of Environmental Quality Administered Programs
Michigan Department of Environmental Quality, Surface Water Division

Current Lake Michigan projects of the Michigan Department of Environmental Quality Surface Water Quality Division will be presented. This will provide an overview of programs and projects.

Communities in Action: Michigan's Areas of Concern Program
Dr. Roger Eberhardt, Michigan Department of Environmental Quality

The five areas of concern on Lake Michigan in Michigan have initiated and sustained a wide range of local actions to protect and restore water quality. These actions collectively serve as a model for community-based environmental protection in the Lake Michigan basin. A summary of actions for the past five years will be presented and the relationship of these actions to the overall area of concern program and the Lakewide Management Plan will be discussed.

Innovative Agriculture and Water Quality
Russ LaRowe, Michigan Agricultural Stewardship Association

A slide presentation will highlight farmers who have adopted innovative practices that increase profitability and protect the environment.

Initiatives to Protect Habitat
Thomas Anderson, Save the Dunes Council, Executive Director

Growth and development threaten air and water quality, as well as our remaining natural areas in the Lake Michigan basin. A new development, Coffee Creek Center, provides an alternative to usual practices. This 640 acre project will save 200 acres. Key to the mixed-use, pedestrian centered CCC is the protection of almost 200 acres of forest, prairie, and wetlands to be owned and managed by Coffee Creek Watershed Conservancy.

Lake Michigan Sand Dunes: Strategies to Protect an Irreplaceable Natural Wonder
Tanya Cabala, Lake Michigan Federation

Lake Michigan is the home of a truly marvelous natural resource - unique and internationally famous freshwater sand dunes. Found in the largest concentration along the eastern shore of Lake Michigan, these sometimes massive natural landforms are a significant draw for the regional economy, especially drawing tourists from states throughout the nation and from other countries. Millions of people tour the dunes annually and visitors to the Indiana Dunes National Lakeshore have produced a regional cash flow of $128 million dollars annually.

The dunes provide critical shelter for coastal marshes, help protect shoreline communities from severe weather and provide a high quality of life for residents and visitors alike. The dunes are also a tremendous ecological resource, supporting more unique species and communities than any other part of the Great Lakes system. The dunes are extraordinary and valuable because of their important plant and wildlife species, their proximity to freshwater, and the diverse environmental settings and microclimates they support.

Once sand dunes are gone, they cannot be created again. They are irreplaceable. In Michigan, however, this outstanding natural resource has been depleted for decades by mining, which continues to this date. Foundries use the sand in molds to produce metal parts for car and airplanes. Dune sand is considered a good sources of sand for the foundries because of its high silica content and sorting by wind and waves. Dune sand is also accessible and very cheap. It is sold to the foundries for $5 to $10 a ton. Not all foundries use dune sand. There are inland sand deposits suitable for use in foundries. What is an equitable way to reduce and eventually eliminate mining in the dunes? This session will provide an overview of sand dune mining and generate discussion on potential strategies for future protection efforts.

Enhance Habitats, Water Quality and Education with Native Plants
Kathy Evans, Muskegon Conservation District

This slide presentation will demonstrate how the Muskegon Conservation District is using Michigan native plants to address education, land use planning, habitat restoration and water quality programs in Muskegon County.

Several examples of volunteer and other community based projects, along with the types of native plants used, will be described. The presentation will include highlights of the Michigan Association of Conservation District's Native Plants Program.

Handouts, including pamphlets on Michigan's native trees, shrubs, wildflowers, vines, grasses and sedges along with a source list of nurseries who provide them, will be available for breakout session participants.

Breakout Session 6
Theme: **Lake Michigan Potential Damages Study Workshop**

Lake Michigan Potential Damage Study – Background and Scope

Roger Gauthier, U.S. Army Corps of Engineers, Detroit District

The U.S. Army Corps of Engineers and key cooperators have initiated and are currently conducting a Lake Michigan Potential Damages Study (LMPDS) to assess potential shoreline damages due to changes in Lake Michigan water levels over the next 50 years. Initiated in 1996, the study is intended to satisfy several key recommendations of the 1986-1993 International Joint Commission (IJC) Great Lakes Levels Reference Study. Lake Michigan was chosen as the prime development area since it has severe erosion problems and experienced the most damage during the previous high water periods in the 1970s and 1980s. LMPDS participants include international and regional entities (the IJC and Great Lakes Commission), state agencies (including Illinois, Indiana, Michigan and Wisconsin), and academic institutions (Sea Grant Universities, etc.).

The IJC Great Lakes Levels Reference Study recommended that the economic value of all shoreline interests be objectively assessed in terms of "potential damages." Potential damages were defined as those that may occur under differing hydrologic conditions, either extremely higher or lower ranges than were recorded over the last 150 years, or alternative anthropomorphic controls of lake level (regulating outflows from lakes Superior and/or Michigan-Huron). The objective of the LMPDS is to create a modeling procedure for estimating economic effects of lake level changes and related social, environmental and cultural impacts. The LMPDS modeling approaches are expected to be the framework for economic assessments for each of the other Great Lakes. The environmental consequences of extreme lake level fluctuations are also expected to be briefly addressed. These include impacts to fisheries, habitat diversity, endangered and threatened species, and archaeological and special natural features.

Water Level Extremes

Roger Gauthier, U.S. Army Corps of Engineers, Detroit District

Evidence exists that water levels have been much higher and much lower than what has been experienced over the past 150 years since water levels have been recorded in Lake Michigan. The lake may actually be at the top of a longer duration high water cycle and could be destined for much lower levels in the near future. There is a need to develop a clear understanding of the relative risk of water levels reaching or exceeding recorded extremes over the next 50 years. A colloquium was held in April 1999 to generate an executive-level summary of previously published studies and current expert wisdom on the historic range of water levels for each of the Great Lakes over the

current millennium (1000-2000). This summary compares and contrasts recorded water levels for Lake Michigan with other Great Lakes given current research.

In addition, a series of alternate hydrologic scenarios have been generated based upon stochastic techniques for each of the Great Lakes. These synthetic times series generally represent similar conditions as seen in the recent past and plausible extreme conditions that could occur over the near future. The alternative hydrologic scenarios are related to the paleo water level evidence to add credence to their use in risk-based analysis.

The alternate hydrologic scenarios are coupled with storm surge and backwater models to factor in disturbed water level characteristics (surf, wave energies, wave uprush, drawdowns, etc.) on the nearshore zone or upstream in the interconnected river mouths along Lake Michigan.

Erosion and Sediment Budgeting
Dr. Robert B. Nairn, P.E., Baird and Associates, Limited

Baird and Associates have been tasked with creating a flood and erosion prediction system (FEPS) which could be used to forecast coastal dynamics for the near- and long-term along the Lake Michigan shoreline. The FEPS is linked to a Geographic Information System (GIS) to assess economic and environmental consequences of variable Great Lakes water levels and human actions. Erosion is described for both cohesive and sandy shores. The FEPS includes numerical models for wave climate, wave propagation, nearshore erosion processes, bluff failure mechanisms, and flood inundation and low water extent mapping.

The FEPS has been applied to shorelines in Berrien, Allegan, and Ottawa counties in Michigan and Ozaukee, Sheboygan, and Manitowac in Wisconsin. Inputs to the system include recession rates, water levels and wave climate, topographic and bathymetric data, subaqueous sediment conditions, current and forecasted shore protection, geomorphic conditions, bluff stability factors and sediment budgeting estimates. The output from the erosion prediction component are future bluff crest positions and uncertainty bands.

The FEPS is designed to be a nearshore sand management tool for lakewide application. In particular, the FEPS is being used to determine the role of shore protection: a) in slowing or postponing bluff or shoreline retreat; b) in modifying the sediment budget by reducing the total supply of beach sediment to the littoral system; c) on its own performance, life expectancy and costs; and d) on its impacts on littoral transport of substrate for reliant habitats along the shorelines and at harbor mouths.

Flood and Low Water Damages
Dr. Mary Ann Heidemann, Wade-Trim Associates

Wade-Trim has been tasked to develop damage estimation techniques for residential, commercial, industrial, institutional, and community-based property losses which would occur under various water level scenarios. This work includes updating land use projections for selected prototype counties along the Lake Michigan shoreline. Damage estimates are being generated for all riparian interests and will be reported as a function of ten-year increments over the next 50 years.

Riparian damage categories include single- and multi-family residential, manufacturing and shipping, retail and other commerce, parks and recreational facilities, commercial fishery, and structural works in place for these facilities to protect them from coastal flooding and/or erosion. The damage estimation methodology includes estimation of community-based property losses such as those to roads and other transportation infrastructure, to water supply and wastewater treatment, and to tourism.

Damages can occur to land, structures, contents, or take the form of emergency assistance. The value of economic loss associated with lakefront land is especially complex. The value of lakefront property can be more a function of frontage than area. Damages are also differentiated by cause, either by erosion, flooding, wave attack, or low-water conditions. In the case of low lake levels, damages also can include economic loss associated with loss of use or additional maintenance costs (i.e., dredging, pumping, etc.) Expected damages can also change over time. As more development occurs, more structures are potentially subjected to damage. Likewise as more development occurs, values typically appreciate.

Land Use and Planning Issues
Dr. John Warbach, Planning and Zoning Center

Management of the land in the coastal zone will come under increasing scrutiny as the value of those lands skyrocket and changing lake levels affect the use of those properties and structures on them. This presentation will look at past management practices and offer thoughts on how coastal land management may change in the future, in response to lake level change. Management practices discussed include shoreline protection, residential and commercial construction land use regulation, public infra-structure and land planning and management plus others.

Environmental Considerations in Coping with Water-Level Changes
Dr. Douglas Wilcox, U.S. Geological Survey, Great Lakes Science Center

Wide seasonal and annual variations in water levels are a distinguishing feature of the Great Lakes. They play an important role in determining the health and diversity of nearshore habitats, especially wetlands, and are a primary control on shoreline behavior. Periodic high water years cause the die-back of invading upland plants and canopy-dominating emergent plants such as cattails. Ensuing low water years expose

the sediments and allow a wide variety of plants to grow from seed. This diverse habitat for fish and wildlife eventually gives way to the dominant species, but the next high water year starts the cycle again. When water levels are regulated and the extremes do not occur, the most diverse portion of wetland habitat shrinks in size.

The impact of water-level changes on shorelines varies with the morphology, composition, and dominant processes of the coast. Variability in lake levels causes erosional and depositional processes to take place at different elevations over time. The most dramatic effect is the impact of an elevated storm surge during high lake levels, flooding low lying areas and eroding mobile substrates. These storms can liberate sediment from upland areas, feeding the littoral system, and ultimately nourish downdrift shorelines. The effects of this nourishment may not be seen until times of low water levels when exposed sand bars, widened beaches, and dune growth are observed. Storms during low phases, although less dramatic in their immediate effect, erode the nearshore bottom, undercut structures, and set the stage for possibly more erosion during the next high stage. Compression of the range of fluctuations does not reduce erosion, it simply focuses it within a narrower elevation range. Attempts to control or ameliorate erosion using revetments, groins, breakwaters, and beach nourishment further disrupt coastal processes and impact not only the beach ecosystem but also many wetlands that rely on the protection provided by barrier beaches.