ABSTRACTS

Lake Michigan: State of the Lake 2001

November 6-7, 2001

A Conference Convened by the Grand Valley State University Annis Water Resources Institute in Cooperation with the United States Environmental Protection Agency Lake Michigan Forum

Abstracts are listed in alphabetical order by first author.

Historical Photo Analysis for Recession Rate Calculation

Greg Anderson and D.G. Dickason, Western Michigan University, GIS Research Center

This presentation will describe the rationale and methodology used to produce a multi-temporal record of bluff top and toe in Allegan and Ottawa County. The discussion will detail the steps taken for acquisition and registration of historical air photos to modern ortho photography. Issues such as lack of visible reference points and points that have been relocated will be addressed.

Historical photography becomes usable as a base to locate bluff top and toe once it has been properly registered and warped. Interpretation of bluff features can be extremely challenging due to the scale of the photography and other limiting characteristics. Characteristics of the photos such as "leaf on" versus "leaf off" and black and white versus color IR will be contrasted. Visual examples will be used to demonstrate the degrees of confidence that are assigned to bluff features. Also shown with visual examples will be areas that have undergone drastic change.

Zebra Mussels, Round Gobies, and Eurasian Ruffe: Predicting Ecological Impacts of the 'Exotic Triad' to Improve Control (POSTER)

Candice R. Bauer and Gary A. Lamberti, University of Notre Dame, Department of Biological Sciences
Martin B. Berg, Loyola University-Chicago, Department of Biology

The Great Lakes have been subject to numerous human-mediated species invasions since European settlement, including the recent Ponto-Caspian aquatic invaders Eurasian ruffe (*Gymnocephalus cernuus*), round gobies (*Neogobius melanostomus*), and zebra mussels (*Dreissena polymorpha*). These three exotic species, which we call the 'exotic triad,' have the potential to significantly impact Lake Michigan benthic communities due to their ability to reach locally high abundances and their expanding ranges, which may converge in Lake Michigan in the near future. For example, zebra mussels are known to foul hard substrates and alter ecosystem processes due to their filtering ability, while ruffe and gobies may compete with native fish for food, refuge from predators, and spawning sites. Native fishes that have shown recent population fluctuations, such as the commercially important yellow perch (*Perca flavescens*) in Lake Michigan, may be adversely affected by increased competition for benthic resources.

The major goal of our research is to determine the potential ecological impacts of the 'exotic triad' on benthic ecosystems and the yellow perch population of Lake Michigan to help inform management and control decisions. In the laboratory, we are quantifying the food and habitat preferences of gobies, ruffe, and perch, as well as determining the outcome of interspecific competition in the presence and absence of zebra mussels. In the field, we are analyzing gut contents of fish collected throughout the upper Great Lakes. Our results will help to target control and prevention measures for appropriate sites and fish populations.

Lake Michigan Lakewide Management Plan (LaMP): Measuring Progress

Judy Beck, United States Environmental Protection Agency, Region 5

In April 2000 the Lake Michigan Lakewide Management Plan (LaMP) was released. The report provides the status of the lake, causes and sources as far as our knowledge allows, and suggested goals, objectives and actions. The next step in the process is to clarify the targets and measures for the goals. To that end a number of meetings were held around the basin in the summer and fall of 2001 to solicit public input. Results of those meetings will be summarized and your input throughout this conference will be sought in order to finalize the targets. The targets are divided into Chemical, Physical and Biological. There is also a stewardship component.

Stewardship Indicators for the Great Lakes: Progress Toward Their Development

Paul Bertram, United States Environmental Protection Agency

Shortly after the 1987 revisions to the Great Lakes Water Quality Agreement, activities were begun to establish ecosystem objectives for each of the Great Lakes and to identify indicators of progress toward those objectives. "Stewardship," i.e., human attitudes and actions toward the Great Lakes, was soon recognized as an environmental category for which objectives and indicators should be developed, and attempts were made to identify appropriate indicators.

The biennial State of the Lakes Ecosystem Conference (SOLEC) was established to provide the governments of Canada and the United States a venue to assess and report on the condition of the Great Lakes based on accepted indicators. The information is intended to strengthen decision-making concerning management of the Great Lakes. Indicators necessary and sufficient to assess the Great Lakes ecosystem components were identified and introduced in 1998 for nearshore and open waters, coastal wetlands, nearshore terrestrial, land use, human health, stewardship, and "unbounded."

Unfortunately, indicators of stewardship are among the least-well developed in the SOLEC suite. Several projects are currently underway to help identify and develop stewardship indicators for the Great Lakes basin. Strong linkages exist between SOLEC indicators and those identified for the Lakewide Management Plans, and there is a clear recognition that stewardship indicators developed through the SOLEC process should be applicable to the LaMPs. Suggestions for the process and for the indicators are welcomed.

Near-Real-Time Monitoring of Pelagic Water Quality in Lake Michigan (POSTER)

Harvey Bootsma, Kathy Graff, and John Zastrow, University of Wisconsin-Milwaukee, Great Lakes WATER Institute

Conventional limnological monitoring methods on large lakes provide data on time scales of weeks to months. While these data can provide information on general seasonal trends, very little is known about short-term (hourly to daily) dynamics of thermal structure, chemical structure and phytoplankton dynamics in large lakes. We have installed a pelagic water quality monitoring buoy in Lake Michigan for the purpose of collecting high frequency (twice daily) vertical profiles of water quality parameters, including temperature, conductivity, dissolved oxygen, pH, redox potential, irradiance, turbidity, and algal fluorescence. The buoy is also equipped with meteorological sensors. Data are retrieved daily, and are made available on an interactive database website. This poster presents preliminary data, and provides an introduction to the water quality database and website.

Restoring Lake Michigan Urban Aquatic Habitat

Joel Brammeier, Lake Michigan Federation

Sections of the city of Chicago's south lakefront have historically been marked by limited accessibility and minimal ecological value. Shoreline structures generally consist of wood and stone revetments designed to minimize erosion. As a result, the city's shoreline landscape is often cut off from its natural connection to Lake Michigan.
The revetments have the negative effect of providing little aquatic habitat and impeding the ability of citizens to access or view a natural land-water interface.

Despite these problems, the area continues to function as a major migratory bird flyway and other portions of the lakefront have tremendous potential to supply high quality aquatic habitat. The region is currently undergoing a radical redevelopment designed to enhance the ecological character of the south lakefront. The Lake Michigan Federation began work with the city government in 1999 as a partner in the redevelopment process and has since cultivated a strong, productive relationship between city agencies and the Chicago environmental community. Central to this relationship is the concept that the natural connection between the city of Chicago and Lake Michigan must be reestablished.

This presentation will articulate specific habitat restoration plans for several sites on the south lakefront, including the land that currently hosts Meigs Field airport. The unique challenges posed by habitat restoration in an urban setting have provided an unprecedented opportunity to meld concerns of community leaders, environmental groups, government agencies, and individual volunteers from the Chicago region into an action plan for aquatic habitat recovery. We intend for the Chicago experience to serve as a guide for other urban centers interested in aquatic habitat restoration projects.

Comparative Spatial Distributions of Salmonines in Lake Michigan (POSTER)

Shannon J. Brines, Edward S. Rutherford, and Tomas O. Hook, University of Michigan School of Natural Resources and Environment, Institute for Fisheries Research

Salmonines support the most economically important fishery in Lake Michigan, and thus appreciating the sustainability of the lake for these predators is of high interest. Diet studies indicate most salmonines share a common prey resource, alewife *Alosa pseudoharengus*, but the degree of spatial and temporal overlap in salmonine distributions is unknown. Spatial distributions of salmonines in the Great Lakes have typically been inferred from spatially and/or temporally constrained studies. To evaluate the degree of horizontal overlap among Lake Michigan salmonine distributions, we used GIS to map catch per unit effort data (CPUE) of chinook salmon *Oncorhynchus tshawytscha*, coho salmon *O. kisutch*, anadromous rainbow trout (steelhead) *O. mykiss*, lake trout *Salvelinus namaycush* and brown trout *Salmo trutta* collected during 1992-1997. We used 10 minute by 10 minute fishery statistical grid cells as the spatial analytical unit. We assumed average angler CPUE data indexed monthly spatial distributions of salmonines from April through October. Results indicated horizontal overlap among salmonine CPUE was minimal and spatial statistics confirmed that negative correlations were significant. Salmonine distributions appeared to be influenced by temperatures and spawning migrations. Further, salmonines in Lake Michigan may limit inter-specific competition by spatially partitioning food resources.

Overview of Environmental Protection in Land Use Plans of Coastal Lake Michigan Communities

Tanya Cabala, Lake Michigan Federation

The Lake Michigan Federation has researched elements of environmental protection incorporated in a sample population of Lake Michigan coastal communities in order to establish a baseline database of the extent of protection in master land use plans, associated ordinances, policies, and enforcement. We will provide an analysis of the land use protection status around Lake Michigan and recommend a range of protection options for consideration by Lake Michigan communities.

Increasing Public Involvement in Sediment Cleanups

Tanya Cabala, Lake Michigan Federation

Contaminated sediment on the bottom of the Great Lakes and its tributaries and inland lakes has been receiving more attention recently from state and federal environmental agencies. Once thought “out of sight, out of mind,” sediments contaminated by wastes from pipes; runoff from streets, parking lots, and farms; and toxic chemicals from air pollution are now considered a serious environmental problem. Fish “take up” pollutants from the sediments when they feed on bottom dwelling or benthic organisms and pass them on to humans when they are eaten.

Lack of public involvement has been recognized as a primary obstacle to successful remediation of contaminated sediments in Great Lakes Areas of Concern (AOCs). Effective community based participation in the AOCs is necessary to initiate, move forward, and ensure successful sediment cleanups.

Funding of cleanups has increased, i.e., the Clean Michigan Initiative, and proposed federal "legacy" legislation and an increasing number of contaminated sediment cleanups are underway or in the planning stages. Unfortunately, AOC communities are not now equipped to fully participate in these efforts as funds for public advisory councils and their education and outreach efforts continue to dwindle. Because contaminated sediment cleanups are lengthy, complicated, costly, and controversial, communities need to maintain and expand their role in the decision-making processes.

Local officials, public advisory councils, and other community-based organizations in AOCs require substantial education and information on the science and technical issues related to contaminated sediments, especially regarding remedial options, and assistance in dealing with the myriad of agencies and legal jurisdictions involved. Local leaders also need specific assistance in identifying effective decision-making models and outreach strategies, and in learning how other AOCs achieve community consensus on remedial options so they do not expend valuable time and energy reinventing the wheel.

To respond to this need for improved public involvement, the Lake Michigan Federation, working with the White Lake Public Advisory Council (PAC), pioneered an innovative approach in the White Lake AOC in Muskegon County, Michigan, aimed at developing a community decision-making model to facilitate increased and effective public involvement in contaminated sediment cleanups. The Federation carried out a model decision-making process that combined education and outreach, in conjunction with the state's effort to proceed with a cleanup of contaminated sediments in Tannery Bay, White Lake.

The Michigan Department of Natural Resources Lake Michigan Fisheries Research Program

Dave Clapp, Michigan Department of Natural Resources, Charlevoix Research Station

The mission of the Michigan Department of Natural Resources Fisheries Division Research and Evaluation Program is to provide information, models and advice to make possible science-based management of Michigan's fishery resources. For almost 35 years, the Department has maintained a research station on Lake Michigan at Charlevoix. The station facilities include laboratory areas and equipment, a 20' boat for inshore work, and the 63' Survey Vessel *Steelhead*. Initially, the research conducted at the Charlevoix station focused on assessment of commercially important fish species including lake trout, lake whitefish, and bloater chubs. In the 1980's and 1990's, research activities were expanded to include recreational creel surveys, studies of introduced salmonids, and evaluation of inshore fishes such as yellow perch and round goby. Charlevoix researchers are involved in significant collaborative research efforts with personnel from other state and governmental agencies as well as many of the universities in the Great Lakes region. This work includes lake trout early life history research, population modeling efforts, and studies of salmonid condition and disease. Much of this lakewide research activity is based on priority areas defined through the Great Lakes Fishery Commission Lake Committee structure. This presentation will describe the MDNR's Lake Michigan program and discuss likely future research directions and collaborations for the station.

Quantifying the Impact of Dams on Anadromous Fish Production in Great Lakes Tributaries (POSTER)

Sara Creque, Edward Rutherford, James Diana , University of Michigan
Paul Seelbach, Kevin Wehrly, Michigan Department of Natural Resources
Jeff Tyler , Worcester Polytechnic Institute

Although there are thousands of dams on Great Lakes tributaries, there has been relatively little work evaluating the impact dams have had on anadromous fish populations in this region. In this study, potential populations of Chinook salmon, Brown trout, Steelhead, Walleye, White sucker, and Lake sturgeon above dams, given removal or fish passage, will be estimated for several Great Lakes tributaries that represent a variety of hydrologic and thermal regimes. The multiple linear regression models and valley segment type extrapolations used for predictions are based on over 420 sites from the Michigan Rivers Inventory and other sources. Preliminary results from the Manistee River show that Chinook and Steelhead smolt production would increase by 60,000 and 50,000 respectively in the mainstream and Pine River if Tippy Dam were removed.

Clearwater Plaza: An Opportunity for Cooperative Research on Water Quality Improvement

Mackenzie L. Davis, Michigan State University, Department of Civil and Environmental Engineering

The Monroe Avenue water treatment plant in Grand Rapids, MI (renamed Clearwater Plaza) is being renovated to house a research facility. This facility will provide an opportunity to integrate research on watershed management and water treatment to protect the public health. An overview of the research paradigm will be presented. A progress report on development of the research facility will include a presentation of the proposed facility capabilities. The status of renovation and progress in creating the endowment to support its operation will also be presented.

Land Use/Cover Updates and Change Analysis in Coastal Counties

Rod Denning and Jean Conzelmann, Grand Valley State University, Annis Water Resources Institute

Understanding how land use/cover conditions are changing is key to understanding the impacts that change is having on our water resources. As part of the Lake Michigan Potential Damages Study the Annis Water Resources Institute updated the land use/cover information for shoreline communities in Antrim, Emmet, and Charlevoix counties. The original (1978) Michigan Department of Natural Resources MIRIS land use/cover inventory was used as a starting point for the current update. This presentation will address the procedures used, problems encountered and the results of the update (1998 -1999) and change assessment.

Advances in Our Understanding of Sediment-Water Exchange and Sediment Transport from the Lake Michigan Mass Balance and Episodic Events Programs

B.J. Eadie, J.A.. Robbins, D.J. Schwab, P. Van Hoof, NOAA Great Lakes Environmental Research Laboratory
K. Hornbuckle, University of Iowa
T.H. Johengen, Cooperative Institute for Limnology and Ecosystem Research

In the LMMB program, we were able to sample and analyze the most detailed set of sediments ever collected from Lake Michigan. These data provide us with detailed spatial distributions, current accumulation rates, and inventories of numerous constituents. In the episodic events (EEGLE) program we are exploring the impact of winter and early spring storms that massively resuspend materials with characteristics of sediment depositional regions and transport these materials throughout the lake. We have calculated that large events can resuspend over one million MT of particulate matter, similar to the estimated external input into the lake. Several years of sediment trap collections at offshore sites show a range in mass and nutrient fluxes that span a factor of ten. The internal recycling of sediment-associated constituents is very important in the long-term behavior of these materials and the exposure of biota.

An Evaluation of Spawning Activity by Lake Trout in Northeastern Lake Michigan

John D. Fitzsimons, Dept. of Fisheries and Oceans, Ontario
Jory Jonas, Michigan Department of Natural Resources
Randy Claramunt , Little Traverse Band of Odawa Indians
Ellen Marsden, University Vermont

Historically, nearly half of the commercial catch of lake trout from Lake Michigan came from the northeast section suggesting that a high proportion of spawning reefs were also located there. We evaluated a large number of the putative historically important reefs in northeastern Lake Michigan for spawning substrate suitability and measured egg deposition at a smaller number of nearshore and offshore reefs. Based on an initial reconnaissance survey, few of the sites evaluated had the requisite spawning habitat characteristics (steep slope, cobble substrate, deep interstices) thought to be important based on extensive work in the other Great Lakes. When measures of egg deposition were made at sites believed to have the requisite characteristics, deposition (0-130 eggs$\bullet m^{-2}$) was low to non-existent. Measurable egg deposition only occurred on shallow nearshore sites with the highest deposition on a rock-filled crib adjacent to shore at a water depth of 2 m. Based on this first year of a three-year project, the most outstanding contributor to an apparent low reproductive output was the extremely low level of deposition. Of less importance were the relatively high numbers of potential interstitial egg predators, dominated by crayfish, and the shallow nature of the spawning habitat used.

Lake Michigan Potential Damages Study Workshop Findings & Recommendations

Roger Gauthier, United States Army Corps of Engineers, Detroit District

The LMPDS workshop presented a wide range of ongoing tasks on the Lake Michigan Potential Damages Study. This presentation will provide a wrap-up summary of the information presented, issues raised during the workshop, and a vision for the future of the project.

The LMPDS was designed to develop a methodology for investigating the impacts of extreme water levels. One of the primary goals of the project is to share knowledge gained with local experts and decision-makers to improve understanding of coastal issues and coastal zone management. This final session of the workshop will outline critical future steps for the project and underscore continued cooperation between local and federal entities.

Current Estimates of Atmospheric-Water Exchange of PCBs from the Lake Michigan Mass Balance Study: A Historical Comparison

Mark L. Green, State University of New York at Buffalo, Department of Civil, Structural and Environmental Engineering
Joseph V. DePinto, Limno-Tech, Inc.

As part of the Lake Michigan Mass Balance Study, PCB mass flow across the air-water interface of Lake Michigan has been calculated on a high resolution (25 km^2) spatial basis and daily temporal basis. The loading was calculated from October 1994 to September 1995 to yield an annual estimate. A gross depositional atmospheric loading of ~3200 kg ΣPCB to Lake Michigan was estimated for this period, while the net air/water exchange (absorption – volatilization) for the same period was estimated to be ~1900 kg ΣPCB (net volatilization from the lake). The high spatial resolution of our data modeling allowed an estimate of the atmospheric contribution of the Chicago urban complex contributes to the lake. We computed that approximately 10% of the gross depositional loading to Lake Michigan annually came from the Chicago source area. Also, using the current atmospheric ΣPCB concentrations, an air-equilibrated water phase concentration of 0.11 ng/L ΣPCB was estimated from a summation of 33 congener groups. This estimate is significantly higher than previous estimates of 0.032 – 0.070 ng/L ΣPCB for the air-equilibrated water phase concentration. Important insights on the whole lake dynamics are reported in comparing the current mass flow estimates with the historical simple average approach.

Use of Native Weevil as a Biological Control for Eurasian Watermilfoil in Michigan

Hamdy Helal. West Shore Community College, Aquaculture & Natural Resources Institute

In the summer of 1999, about 10,000 native weevils (*Euhrychiopsis lecontei)* were planted in three different sites in both the south branch and the marsh of the Pentwater River (Oceana County). The south branch of the River flows from east to west and joins the north branch to form the marsh of the Pentwater River just east of Pentwater Lake. This lake connects westward to Lake Michigan through a short channel. The weevil planting took place to enhance the indigenous population density of the native weevil in order to control the nuisance growth of the exotic Eurasian Watermilfoil (*Myriophyllum spicatum).* The planting sites were selected where we found heavy growth of Watermilfoil (EWM). About a month before planting the weevils, we surveyed the relative density of EWM in the marsh and the river. After planting the weevils, we examined monthly quantitative samples of the submerged plant community up- and down-stream of the weevil sites during summer-early fall period. Our focus was to estimate the percent contribution of EWM stem density relative to the total submerged plants. This sampling lasted, during summer and early fall season, from July1999 until September 2001.

The 1999 EWM samples indicated a sharp decline in this nuisance plant population as a result of planting the weevil's herbivore larvae. The subsequent samples of the 2000 and 2001 seasons

indicated that EWM population has been drastically reduced to almost non-existence in the Pentwater River and marsh. Climatic factors affecting water level or flow in the river are probably having an impact on the subsequent establishment of EWM population in this section of the Pentwater River. For example, the rate of rainfall, accompanied by shifting of sand particles on the bottom of the river after heavy rain, negatively impacted the existence of this exotic plant. This study indicates the validity of using the herbivorous impact of this native weevil's larvae in order to biologically control the exotic EWM. A video presentation showing adult weevil and the eating habits of its larval stage will be shared during the talk. In addition, I will review reports pertaining to using this weevil in other inland lakes in the State of Michigan.

Dynamics of Alewife Production and Potential Recruitment in Lake Michigan Habitats* (POSTER)

Tomas O. Höök and Edward S. Rutherford, University of Michigan School of Natural Resources and Environment Institute for Fisheries Research
Doran M. Mason and Glenn Carter, NOAA Great Lakes Environmental Research Laboratory

Essential fish habitat may be defined as areas where fish densities, growth, survival, and/or production rates are relatively high. In Lake Michigan, coastal embayments and drowned river-mouth habitats are warm and highly productive relative to open lake habitats, and may contribute disproportionately to recruitment success of key species like alewife *Alosa pseudoharengus*. To test this hypothesis, we began a major field and modeling program to estimate young-of-year (YOY) alewife production and potential recruitment in drowned river-mouth environments and in nearshore regions of Lake Michigan. Alewives, their prey and predators were sampled using plankton nets, hydroacoustics and trawls. Here, we present preliminary results of spatially referenced information on prey and predators of YOY alewife, and alewife abundance, growth and survival. This information is then used in a spatially explicit bioenergetics model to estimate spatial dependence of production and visualized using Geographic Information System software.

*Funding provided by the Great Lakes Fisheries Trust

Ecological and Economic Consequences of Hydropower Related Watershed Restoration on Salmonid Production in the Manistee River (POSTER)

Brad Horne, Ed Rutherford, Michael Moore, Matt Kotchen, University of Michigan School of Natural Resources and Environment
Frank Lupi, John Hoehn, , Michigan State University, Department of Agricultural Economics
Kevin Wehrly, Michigan Department of Natural Resources, Fisheries Division

Dam re-licensing provides a unique opportunity for watershed restoration of Great Lakes tributaries. We conducted a study of the ecological and economic impacts of restoring natural flows to the Manistee River, a Lake Michigan tributary in northwestern lower Michigan. Two dams on the Manistee River were re-licensed by the Federal Energy Regulatory Commission (FERC) in 1994. For the benefit of downstream biota, these licenses required dam owners to switch from peaking flows, in which two 10-year flood events were released each day, to run-of-river flows, in which water is continuously released. Our research has determined that restoration

of natural flows has affected two recreationally and economically important salmonid species in different ways. Flow stabilization has increased reproduction success of chinook salmon and steelhead trout, but increased survival and abundance only for young chinook salmon. In contrast, survival and abundance of young steelhead, which must remain in the river longer, is limited by lethal high summer temperatures. While the change in hydropower operations has increased the costs incurred to meet peak power demand, these costs are more than compensated for by societal benefits resulting from using a cleaner fossil fuel mix for altered hydropower production, and from increased recreational opportunities available to Lake Michigan anglers.

Simulating Effects of Hydro-dam Alteration on Thermal Regime and Wild Steelhead Recruitment in the Manistee River, Michigan (POSTER)

Brad Horne and Ed Rutherford, University of Michigan School of Natural Resources and Environment
Kevin Wehrly, Michigan Department of Natural Resources, Fisheries Division

Hydroelectric dams may affect anadromous fish survival and recruitment by limiting access to upstream habitats and adversely affecting quality of downstream habitats. In the Manistee River, a tributary to Lake Michigan, two hydroelectric dams limit recruitment of wild steelhead (*Oncorhynchus mykiss*) by increasing tailrace water temperatures to stressful levels thereby significantly reducing survival of young-of-year (YOY) fish. The objectives of this study were to use temperature models, laboratory experiments, and regression analysis to predict the change in river temperature and YOY steelhead production resulting from hypothetical dam removals or bottom-draw retrofits. We used physical process models to predict Manistee River thermal regimes following each dam alteration scenario. We used laboratory experiments and statistical analyses of empirical relationships between temperature and YOY steelhead production to independently quantify potential recruitment of Manistee River steelhead. We found all proposed dam alteration scenarios lowered summer temperatures and increased survival of YOY steelhead in the Manistee River. However, none of the proposed scenarios lowered temperatures sufficiently to increase Manistee River steelhead recruitment as high as that found in other "prime" Great Lakes steelhead rivers. Nevertheless, bottom-draw withdrawal provides the greatest promise for increasing wild steelhead recruitment and decreasing reliance on hatchery stocking by decreasing the likelihood of year-class failures in the warmest summers. We hope that results of this study will foster consideration of alternative mitigation options for Manistee River dams during future relicensing negotiations.

What is the Impact of Rocky Habitats on Lake Michigan Biology?

John Janssen and Harvey Bootsma, University of Wisconsin-Milwaukee, Great Lake WATER Institute

The eastern and western littoral zones of Lake Michigan are, to a large extent very different. Most of the shallow water in Illinois is rocky and large parts of the shallow areas of Wisconsin are also rocky. The rocky area in Illinois has been mapped to some extent, but much less is known about Wisconsin. In Illinois there are about 160 fossil coral reefs of Silurian age and the area between these patches of bedrock is mostly filled with a cobble glacial till. Similar sites occur in Wisconsin. These rocky areas are, for the most part, completely covered with zebra mussels and the interstitial spaces house crayfish, amphipods, mayflies, caddisflies, and many

other aquatic invertebrates as well as sculpins. Wind generated lake currents and upwelling/downwelling events transport water masses onto these rocky areas where zebra mussels consume the base of the midwater food chain. The modified water masses are then transported elsewhere. Rocky areas are also the preferred habitat and spawning areas for many fish, including yellow perch. The zebra mussel induced increased water clarity, consequent increase in benthic productivity, and transport of water masses onto and off the rocks means that these scarcely studied rocky areas are now more important for lake dynamics than before zebra mussels.

Assessment of Transoceanic NOBOB Vessels and Low-Salinity Ballast Water as Vectors for Nonindigenous Species Introductions to the Great Lakes (POSTER)

Tom Johengen, University of Michigan, Cooperative Institute for Limnology and Ecosystems Research
D. Reid and G. Fahnensteil, NOAA Great Lakes Environmental Research Laboratory
F. Dobbs and M. Doblin, Old Dominion University, Dept. Ocean, Earth & Atmospheric Sciences,
H. MacIsaac, University of Windsor, Great Lakes Institute for Environmental Research
G. Ruiz, Smithsonian Environmental Research Center
P. Jenkins, Philip T. Jenkins and Associates Ltd., Ontario, Canada.

Over the last decade, much attention has been focused on ballast water as a vector for nonindigenous species introductions, and on effectiveness of open-ocean ballast exchange as a defense mechanism. Many aquatic organisms are euryhaline and can survive exposure to high salinity or form resting stages that accumulate in bottom sediments and are difficult to remove with exchange. Furthermore, approximately 90% of the ocean vessels entering the Great Lakes are declared NOBOB (no-ballast-on-board) and are not subject to any regulations under existing U.S. and Canadian laws. However, NOBOB ballast tanks contain significant volumes of residual material (water and sediment) representing numerous previous ballasting operations from foreign ports. While operating in the Great Lakes, NOBOB vessels take-on water as ballast that mixes with the residual material and can subsequently be discharged at various ports along their routes. This material potentially contains a wide assortment of viable plants, animals, and microorganisms, including so-called “resting stages”.

This presentation will describe preliminary results from a recently funded multi-disciplinary, science-based study that will evaluate the risk of invasions associated with ocean-going vessels entering the Great Lakes. Our three interrelated research tasks are: (1) Characterization of biological communities and ballast residuals in NOBOB tanks; (2) Ballast tank mesocosm experiments to determine whether resident biota in NOBOB ballast tanks are discharged to the Great Lakes under actual ship operating conditions; and (3) Transoceanic experiments to test the effectiveness of open-ocean exchange. The study is unique in its attempt to directly sample within the ballast tanks and for its comprehensive biological assessment of all organisms, including resting stages and microorganisms.

A Case History of Sea Lamprey Control in Lake Michigan

Dennis S. Lavis, United States Fish and Wildlife Service

The sea lamprey (*Petromyzon marinus*) control program is instrumental in maintaining today's fish community structure. Initial treatment of Lake Michigan tributaries with lampricide reduced the number of spawning-phase sea lampreys by 85%. Sea lampreys were found in 119 of the 511 tributaries of Lake Michigan. The greatest numbers of parasitic-phase lampreys are produced in 34 streams. Between 1960 and 1999, 730 treatments were conducted in 113 Lake Michigan tributaries. The average number of streams treated annually declined during 1970-1979 to 1990-1999. Thirty eight percent less TFM (active ingredient) was applied annually in 1990-1999 than in 1960-1969. Barriers specifically constructed or modified to block migrating sea lampreys are currently found on 12 Lake Michigan streams. The estimated numbers of parasitic-phase sea lampreys in Lake Michigan between 1977 and 1999 range from 32,000 (1979) to 105,900 (1998). The incidence of fresh sea lamprey wounds on lake trout in Lake Michigan was generally less than five per 100 fish in most years since 1971. Lamprey-induced mortality increased steadily in the 1990s. Most mortality was in northern Lake Michigan where lake trout are more likely to be attacked by sea lampreys because of the large lamprey population.

A Dip in the Lake: Coordinating Monitoring in the Lake Michigan Basin

Ric Lawson, Great Lakes Commission

One of the major challenges in managing coastal resources is to cooperatively collect and evaluate critical ecological, economic, and social information. Too often, financial resources dedicated to long-term monitoring are limited, and specific data are collected by a diverse mix of agencies and organizations. The Great Lakes Commission is involved in several efforts in the Lake Michigan basin to coordinate monitoring, and consolidate and disseminate critical information. Our efforts include: monitoring coordination bodies, online monitoring and data inventories, clearinghouses and online mapping, GIS standardization, and indicator development.

This presentation will focus primarily on two such efforts: the Lake Michigan Monitoring Coordination Council, and the Lake Michigan Online Monitoring Inventory. Other associated work such as the Online Atlas, Air Toxics Mapper, and Great Lakes Coastal Wetlands Consortium will also be discussed comparatively. These approaches each address a different aspect of the data collection and communication problem and provide possible solutions to the need for regional data collection and use. This work, in conjunction with the State of the Lake Ecosystem Conference (SOLEC) and Lakewide Management Plan (LaMP) processes, is helping establish a foundation for coordinated monitoring and information use in the Lake Michigan basin.

Environmental Monitoring of Lake Michigan Using CoastWatch Data and JAVA GIS

George Leshkevich and Songzhi Liu, NOAA/ Great Lakes Environmental Research Laboratory and CILER/University of Michigan

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 observation 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 to federal, state, and local agencies, academic institutions, and the public via the Great Lakes CoastWatch web site (http://coastwatch.glerl.noaa.gov). The goals and objectives of the CoastWatch Great Lakes Program directly support NOAA's statutory responsibilities in estuarine and marine science, living marine resource protection, and ecosystem monitoring and management. 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. New utilities such as JAVA based interactive retrieval of physical parameters such as surface temperature, ice cover, winds, and bottom depth at a given location enhance the accessibility and utility of Great Lakes CoastWatch data. Plans include enhancing the present product suite with image products from new satellite sensors such as Synthetic Aperture Radar (SAR) and ocean color sensors.

Temporal and Spatial Distributions and Source Apportionment of Priority Organic Pollutants in Lake Calumet Area, Chicago

An Li, Jae-Kil Jang, and Peter Scheff**,** University of Illinois at Chicago, School of Public Health

Nine sediment core samples, including five deep cores (42-51 cm) and four short cores (8-12 cm), were collected from the Lake Calumet area located 15 miles south of downtown Chicago. The deep cores were sectioned into 10 to 12 segments and dated by Pb-210 radiological technique. The short cores were sectioned into 4 to 6 segments. Loss on ignition (LOI), water content, sediment density, and grain size distribution were determined for each sediment sample. Seventeen polycyclic aromatic hydrocarbons (PAHs) and nineteen polychlorinated biphenyls (PCBs) were analyzed. Highest PAH concentration (20 μg/g) and flux (23 $\mu g/cm^2/yr$) were recorded at a location near the expressway I-94 during the 1980s. The cores collected at locations in the vicinity of a coke oven and a railroad showed PAH concentration maximum during the 1950s to 1960s. The concentrations and fluxes of PCBs varied widely between 1.3 and 654 ng/g, and between < 0.1 to > 500 $ng/cm^2/yr$, respectively. The highest PCB concentration was observed in the segment representing the 1950s at the location closest to the railroad. The fluxes of PCBs into the lake at the locations near expressways and the coke plant increased until the 1980s.

Qualitative identification and quantitative apportionment of pollutant sources are often the prerequisites for developing and implementing effective health intervention and pollution control strategies. For PAHs, isomer ratios and molecular mass profiles have been used since the early 1960s to identify their sources. In year 2000, USEPA released its CMB8.2 computer software, which substantially facilitates the estimation of source contributions to ambient air pollutants such as PMs and VOCs. The model, however, has not been tested for source apportionment of pollutant chemicals found in aquatic environment. In this work, we applied CMB8.2, for the first time, to PAHs found in the sediment of the Lake Calumet area. Source fingerprints were collected from the literature. Seven heavier PAHs were selected as model fitting compounds. The preliminary results indicate the feasibility of using the models. Results showed that coal-related

sources are contributing 64% of the total PAHs in that area, and the remaining were from traffic-related sources.

Great Lakes Water Diversion Policies - Implications for Lake Michigan Communities

Cheryl Mendoza, Lake Michigan Federation

The Lake Michigan Federation will provide an overview of the legal ability to protect the Great Lake from water diversions with an emphasis on the implications of in-basin water use. Increased population growth and lack of water conservation in Lake Michigan shoreline communities weakens the ability to protect Lake Michigan and the other Great Lakes from water diversion proposals from other parts of the U.S. and the world. This presentation will foster an understanding of the need for water conservation in the Lake Michigan Basin and will provide water conservation options for use by communities, businesses, and individuals.

Current Status of the Amphipod *Diporeia* in Lake Michigan

Thomas F. Nalepa and David Fanslow, NOAA Great Lakes Environmental Research Laboratory

We continue to document the spatial extent of the decline in the amphipod *Diporeia* in Lake Michigan. In July/August 2000, we sampled at 158 sites located throughout the lake and compared abundances to abundances found in 1994/95. Over the whole lake, *Diporeia* abundances declined by 68 % between 1994/95 and 2000. Greatest declines occurred in the northern portion of the lake where densities now are near zero at depths shallower than 60 m. The area with few or no *Diporeia* includes northern Green Bay and Grand Traverse Bay. In addition to taking lakewide samples to examine the spatial extent of the decline, we also have been sampling intensively at several 45-m sites along the eastern shoreline extending from St. Joseph north to Muskegon. The rate of decline in *Diporeia* was quite different at each of the sites. At the site off St. Joseph, *Diporeia* declined from 10,000 m^{-2} to 0 m^{-2} in just a 6-month period in 1992. At a site off Grand Haven, *Diporeia* declined to 0 m^{-2} gradually between 1994 and 1998. At the Muskegon site, abundances began to decrease in 1997, stabilized in 1998, and then increased throughout 1999 and into early spring 2000. However, abundances began to decrease again in late spring 2000, and by fall abundances were near zero. Thus, the pattern of decline was different at each site. The decline at Grand Haven and Muskegon coincided with an increase in abundances of zebra mussels, but zebra mussels were never collected at the St. Joseph site. We examine various hypotheses for the decline, including competition for settling food between *Diporeia* and zebra mussels, and potential pathogens such as disease, fungi, or bacteria.

A Watershed Information System for NPS Risk Assessment

Da Ouyang, J. Asher, S. Yi, and J. Bartholic, Michigan State University, Institute of Water Research

Nonpoint source (NPS) pollution, particularly from agricultural runoff, is the leading cause of impairment of the Nation's surface water quality. Identifying, assessing and controlling NPS pollution is still a challenge due to its diffuse nature and many factors involved in the process. It

is critical to develop an information system that is capable of managing multiple data layers with easy access, and providing information which is essential for watershed management and NPS control. The information may include the location of watersheds, identification of high-risk areas such as highly erodible lands, sediment and nutrient contributing areas, and impaired river segments.

By using the Internet technology and a Geographic Information System (GIS), the Institute of Water Research at Michigan State University has developed a watershed information system that can easily be accessed through Internet. This system provides a wide range of information regarding watersheds throughout Michigan including 8-digit and 14-digit watershed boundaries, rivers, wetlands, contours, flow lines, elevations, etc.

The widely used soil erosion model, Revised Universal Soil Loss Equation (RULSE), has also been integrated with GIS and is available on-line. This system is a very efficient tool for field staff to estimate soil erosion and help implement conservation planning. With the development of a spatially explicit sediment and phosphorus loading model, the system will be able to estimate soil erosion, sediment delivery, and sediment and phosphorus load in a watershed.

This watershed information not only provides an inventory of natural resources in a watershed, it also allows users to identify NPS areas and estimate the pollutant loadings. The information system will help watershed planners and other decision makers to prioritize watersheds and identify high-risk areas that may need technical assistance to implement the best management practices for controlling nonpoint source pollution.

Using Artificial Neural Networks, Geographic Information Systems and Remote Sensing to Model Urban Sprawl in Coastal Watersheds Along Eastern Lake Michigan

Bryan C. Pijanowski, Michigan State University. Basic Science and Remote Sensing Initiative

The Land Transformation Model (LTM), which has been developed to forecast urban use changes in a grid-based geographic information system, was used to explore the consequences of future urban changes to the years 2020 and 2040 using non urban sprawl and urban sprawl trends. The model was executed over a large area containing nine of the major coastal watersheds of eastern Lake Michigan. We found that the Black-Macatawa and Lower Grand watersheds will experience the most urban change in the next twenty to forty years. These changes will likely impact the hydrologic budget, may reduced the amount of nitrogen exported to these watersheds, result in a significant loss of prime agricultural land and reduce the amount of forest cover along the streams in many of these watersheds. The results of this work have significant implications to the Lake Michigan Lake Area Management Plan (LaMP) that was recently outlined by the United States Environmental Protection Agency.

Aquatic Nuisance Species and Their Effect on Fisheries

Chuck Pistis and Ron Kinnunen, Michigan Sea Grant Extension

Numerous aquatic nuisance species (ANS) have entered into the Great Lakes region including the ruffe, gobies, spiny water flea, fish hook flea, sea lamprey, zebra mussel, Eurasian watermilfoil,

and purple loosestrife. Many of these species are a cause for concern as they can have impacts on the fisheries in the Great Lakes and their spread to inland locations and other geographic watersheds is of great concern. The potential implication of aquatic nuisance species on the fisheries will be reviewed.

There are many possible vectors for the spread of these aquatic nuisance species, but in recent years baitfish and aquaculture industry practices have been scrutinized as a potential mechanism for furthering the geographic range expansion of aquatic nuisance species. A Great Lakes Sea Grant Network project addressed this issue and the results will be presented.

Evaluation of Techniques Used to Measure the Spatial and Temporal Variability in Natural Recruitment of Chinook Salmon to Lake Michigan

Jeremy Price, Michigan State University, Dept. of Fisheries and Wildlife
Edward S. Rutherford, University of Michigan, School of Natural Resources and Environment, Institute for Fisheries Research
Doran M. Mason, NOAA Great Lakes Environmental Research Laboratory

A perceived imbalance between salmonine predator demand and forage prey supply in Lake Michigan has prompted cuts in stocking of hatchery-produced chinook salmon *Oncorhyncus tshawytscha* and increased reliance on naturally-produced recruits. Chinook salmon have reproduced naturally since their introduction in 1967 and now contribute 2-3 million recruits annually to the fishery. However, differences among methods used to quantify natural recruitment have limited our understanding of causative factors affecting chinook recruitment. To resolve discrepancies among methodologies for understanding factors influencing recruitment variability, we compared techniques traditionally used to estimate salmon recruitments with the potential of fixed-hydroacoustics technology. Previous studies indicated most wild chinook recruits were produced in 4 tributaries: the Muskegon, Manistee, Little Manistee and Pere Marquette rivers. Time-series data indicated annual recruitments varied from 5 to 10-fold in each river. Primary factors affecting spatial and temporal variability in recruitment may have included variation in instream habitat, spawner biomass, temperature and river discharges during egg and fry stages, and instream predation mortality. Comparative estimates of salmon recruitment in the Muskegon River using historic techniques suggest pass-depletion techniques may underestimate, and mark-recapture techniques may overestimate smolt abundance. Traps and hydroacoustics show the greatest potential for obtaining accurate estimates of recruitment.

The Use of Radiometric Dating and Detailed Stratigraphy to Determine the Significance and Fate of Heavy Metals in Drowned-Rivermouth Lakes

Richard Rediske, Grand Valley State University, Robert B. Annis Water Resources Institute

Investigations using ^{210}Pb dating and detailed stratigraphy were conducted to determine the significance and fate of heavy metals in the sediments of White Lake and Muskegon Lake (Michigan). Elevated sediment concentrations of chromium, arsenic, and mercury were found in the vicinity of the historical effluent discharge point of a tannery on White Lake. The chromium levels found in the sediments were among the highest concentrations reported in the Great Lakes basin (20,000 mg/kg). Sediment contamination related to the anthropogenic discharge of heavy

metals was also found in Muskegon Lake. Historically, metal finishing and plating effluents were released into the open water or through storm drains. Since the direct discharge of effluent from the industries located on White and Muskegon Lakes were discontinued in the mid 1970s, vertical depositional patterns may reflect changes in the flux of metals into each system. Historical levels of metals may be covered by less contaminated material or resuspended by physical events. Information on sediment stability and deposition rates was critical to the development of remedial action plans (RAPs) for the lakes.

Traditional sampling and analytical methods would not provide information on sediment stability and accumulation patterns. Radiodating using ^{210}Pb, a technique commonly used in limnology, was employed to determine the history of sediment deposition. This technique was augmented with detailed stratigraphy analysis to provide a current and historical record of heavy metal deposition in the sediments. Two piston core samples were collected in the tannery discharge area and sectioned in 2 cm intervals in White Lake. In Muskegon Lake, one piston core from a stormwater outlet area, Division Street Outfall, and two piston cores from deep depositional basins were collected. Total metals were analyzed by ICP. Radiometric measurements were made using a low-background gamma counting system with a well-type intrinsic germanium detector. Total ^{210}Pb activity was obtained from the 46.5 kev photon peak, and ^{226}Ra activity was obtained from the 609.2 kev peak of ^{214}Bi. The 661.7 kev photon peak was used to measure ^{137}Cs activity. The peak in ^{137}Cs activity was measured to evaluate its usefulness as an independent time marker for the peak period of fallout from nuclear weapons testing in 1962-63.

Chromium stratigraphy in the tannery discharge area of White Lake indicated that the top 15-20 cm of sediment was less contaminated (2,000-4,000 mg/kg) than sediment located at >30 cm (>5,000 mg/kg). Radionuclide results suggested that this surface sediment layer was well mixed, however, distinct from the deeper more highly contaminated sediments. Since the direct discharge of tannery effluent to this area ceased in 1976, evidence of the deposition of sediment with less chromium contamination should have been apparent. The lack of a decreasing gradient of chromium concentration in the near surface zone sediments suggested that the processes of mixing and resuspension continue to be active. Similar results were found in Muskegon Lake. Moderately contaminated, mixed sediments were found in the near surface zone followed by deeper strata with higher concentrations of metals. Depositional patterns followed circulation patterns unique do drowned rivermouth systems in western Michigan. Wind induced currents and wave action along the southwest shore cause resuspension and mixing of contaminated sediments. The resuspended sediment is then readily available for advection to other areas in the lake by currents on the old river channel.

Spatial and Chemical Variability of the Grand River Plume: Summer 2001 (POSTER)

Peter E. Riemersma and Mark Vander Werp, Department of Geology, Grand Valley State University

The objectives of this investigation were to examine the temporal changes in the spatial and chemical configuration of the Grand River plume where it discharges into Lake Michigan in the vicinity of Grand Haven, Michigan. Plume definition and characterization are used to relate the relative influence of variable river discharge, wind velocity, wind direction and water temperature on the plume shape and composition. In addition to its inherent hydrologic interest, the Grand

River is the largest tributary flowing directly into Lake Michigan and is estimated to contribute a large fraction of the chemical load.

Nine cruises aboard the GVSU-AWRI ship *D.J. Angus* were conducted between mid-June to mid-August. During each cruise an average of 12 locations were sampled within and at the edge of the plume. A Sea-Bird Seacat SBE 19-03 was used to measure the variation with depth of temperature, conductivity, irradiance (a measure of the turbidity), chlorophyll concentration and light transmission. Select discrete water samples were also collected and analyzed for conductivity and turbidity.

The detailed vertical profiles of conductivity and irradiance values at the various locations were used to define the boundary between the river plume and the Lake Michigan waters. Our results illustrate the variable horizontal extent and thickness of the plume and they compare the plume volume and distribution to the existing river discharge, wind direction and wind speed conditions. We plan to build and expand upon these results next summer and hopefully incorporate nitrate and phosphorus sampling.

A Technique for Visualizing Spatial Goals for Wetland Restoration in The Great Lakes Basin (POSTER)

Bridget Sass, Barry Bolka, Tom Brody, United States Environmental Protection Agency

Background: This research highlights the need to address the challenge of adequately visualizing spatial relationships for better evaluation and assessment. A project that identified and characterized the wetland areas across the Great Lakes was used to show how visual interpretation can affect the management of wetland restoration and protection.

Method: The National Land Cover Dataset (NLCD; 1990-92) wetland classes 91 (Woody Wetlands) and 92 (Emergent Herbaceous Wetlands) were extracted into an ArcSDE 8.0.2 layer for the Great Lakes Basin. ArcView GIS 3.2 was used to quantify the location and area of wetlands that have been degraded and could be restored. The acreage of desired wetland restoration was shown in different spatial contexts in order to show how these spaces can be perplexing when making environmental decisions,

Result: A clearer understanding of the spatial extent of geographic areas of interest can be obtained by morphing the area of interest. This technique can help decision-makers understand how to achieve their geographic restoration goals. Further research topics include using the technique in an analysis of the Canadian side of the Basin as well as temporal and other geographic constraint considerations.

An Overview of Aquatic Gap Analysis for the Great Lakes Region

Jana Stewart, United States Geological Survey
Donna Myers, Great Lakes Coordinator, USGS, Eastern Region
John Gannon, Science Coordinator, USGS-BRD, Great Lakes Science Center
Steve Aichele, Geographer, USGS–WRD, MI District

An Aquatic Gap program is being proposed for the riverine systems of the Great Lakes region including new projects in the states of Minnesota, Wisconsin, Illinois, Michigan, Indiana, and New York and integration of existing or completed projects in Ohio and Pennsylvania. A pilot study to develop a coastal component for aquatic Gap is also being proposed for the Great Lakes Region. The Great Lakes are the largest system of fresh water on earth and provide habitat for a wide variety of aquatic organisms unique to these systems. The aquatic biodiversity of the region is being threatened due to increased population growth from urban expansion, more intensive agricultural practices, continued logging and coastal zone shoreline destruction.

The feasibility for conducting Aquatic Gap for both riverine and coastal systems will be assessed by summarizing the status and availability of existing data for each of the States, including fish and macroinvertebrate databases, and spatial data layers related to physical characteristics of the land and in-stream habitat. An integrated approach will be developed for Aquatic Gap in the Great Lakes region in which common methods and protocols will be established and results will be comparable across the landscape. A list of stakeholders in the region will be developed and contacted for their input into this effort.

Lake Michigan Potential Damages Study Overview

Marie Strum, United States Army Corps of Engineers, Detroit District

The U.S. Army Corps of Engineers (USACE) Detroit District and key cooperators are conducting the Lake Michigan Potential Damages Study (LMPDS). This study is assessing economic impacts due to potential extreme changes in Lake Michigan water levels over the next 50 years. The objective of the LMPDS is to create a modeling procedure and engineering/management tool for predicting future shoreline retreat and calculating economic damages due to erosion, lake level changes, environmental, ecological and related social/cultural impacts.

Integrating the various data layers into a GIS framework has allowed the LMPDS team to develop automated tools to calculate potential economic damages and assess ecological impacts. This modeling approach also allows the team to investigate hazard mitigation alternatives, such as a revised approach to permitting or increasing setback planning and adherence policies. Once the study is complete, local communities can use the data and GIS tools developed to enhance coastal planning and management decisions, with the goal of reducing economic losses along the open coast.

USGS National Water Quality Assessment (NAWQA) Program: Western Lake Michigan Drainages Study Unit Cycle 2: Understanding the Factors that Govern Water-Quality (POSTER)

Dan Sullivan and Charlie Peters, United States Geological Survey, Water Resources Division

In 1991, the U.S. Geological Survey (USGS) began the National Water-Quality Assessment (NAWQA) program to help meet the need for sound scientific information to describe the nation's water-quality, and to further develop the understanding of the effects of human actions and natural factors on water quality. Fifty-two areas covering the nation's largest river basins and aquifers, known as study units, were assessed during cycle 1 of the NAWQA program (1991 –

2000). Forty-two of the study units will be studied during cycle 2 of the NAWQA program (2001 – 2010). The Western Lake Michigan Drainages study unit was assessed during cycle 1 and will be studied during cycle 2.

The cycle 1 program emphasized the collection of information to describe occurrence and distribution of water-quality conditions in the nation. The emphasis during cycle 2 will shift toward studies that assess trends in water-quality and there will be an increased emphasis on studies that help to develop an understanding of the factors that govern water quality. Studies during cycle 2 will focus on: sources of contaminants, contaminant movement from land surface to and within ground water, contaminant movement from land surface to and within streams, effects of urbanization, response to agricultural management practices, ground water/stream interactions, effects on biota and stream ecosystems, and extrapolation and forecasting.

Michigan Source Water Assessment

Mike Sweat, United States Geological Survey

Michigan has 69 water supplies that use surface-water sources. They provide drinking water to over 50 percent of the state's population, or about 5 million people. The United States Geological Survey (USGS) and Michigan Department of Environmental Quality (MDEQ) are cooperating on a project to assess community surface-water sources. Section 1453a of Public Law 104-182, reauthorization of the Safe Drinking Water Act of 1996, requires Federal guidance and defines State requirements for a source water assessment program (SWAP). The United States Environmental Protection Agency (USEPA) published the State Source Water Assessment and Protection Programs Guidance in August 1997 to assist States in developing an acceptable SWAP. By statute, a state's SWAP must complete assessments for all sources of public drinking water that (1) define source water areas, (2) list potential contaminant sources and contaminants of concern, and (3) determine source susceptibility to contamination. States must then work with public water suppliers to inform the public of these results. Results of the assessments will be presented in reports for each surface water facility.

Inland lake and river intake assessments (9 supplies) are watershed based. The assessment process includes reviewing water quality monitoring records and identifying potential contaminant sources. Great Lakes and Upper Great Lakes Connecting Channels intake assessments (60 supplies) will follow the "Assessment Protocol for Great Lakes Sources" developed by Great Lakes States in USEPA Region 5. Assessments will use local data on land use, contamination sources (sewer outfalls, leaking storage tanks, air deposition, etc.), information from local water plant personnel (intake construction and location, influent quality, effects of weather, lake currents, etc.), and centralized State and Federal data resources (Census data, permitted discharges). A pilot assessment completed for the Alpena, Michigan water supply showed potential influences to the intake from a nearby river, from atmospheric conditions, and from two storm-sewer outfalls. The preliminary Alpena assessment was received favorably by the community, and provides the basis of a source water protection program for the community.

Upper Great Lakes Connecting Channels intake assessments (13 supplies) will also use a two dimensional, hydrodynamic flow model of the St. Clair River – Lake St. Clair – Detroit River system. The flow model will define source water areas, track contaminant source water quality concerns, and assist in developing contingency plans. A partnership established among MDEQ,

USGS, USEPA, U.S. Army Corps of Engineers, and the Detroit Water and Sewerage Department (DWSD), with assistance from Environment Canada, will complete this model, and have received American Water Works Association Research Foundation funds to enhance the model's contaminant tracking abilities.

On a national scale, USEPA guidelines explicitly require involving the public in the SWAP process, and in the release of completed assessments. USEPA, the States, public water suppliers, and other stakeholders throughout the country are developing a National Source Water Protection Strategy. This strategy includes a coordinated effort between Clean Water Act and Safe Drinking Water Act programs to benefit the protection of watersheds and sources of public drinking water, and to benefit future programs and local source water protection efforts. A goal of the Michigan SWAP is that greater public awareness of source water issues will result in local source-water protection initiatives that will protect drinking water while improving watershed protection. Communities can use source water assessments to develop source water protection programs that incorporate watershed management plans and best management practices. MDEQ will use source water assessments to determine future public water supply contaminant monitoring waivers.

The Herbicide Atrazine: Ecological and Drinking Water Exposure Assessments for Lake Michigan And U.S. EPA's Special Review Status

Dennis P. Tierney, Syngenta Crop Protection, Inc.

Atrazine is a herbicide used throughout the Midwestern corn belt, including agricultural regions within the Great Lakes basin. Atrazine has been detected in Lake Michigan open water monitoring sites in the 1990's typically at concentrations less than 0.050 ppb. In 1994, the U.S. Environmental Protection Agency (US EPA) began a Special Review of atrazine. The notice indicated concern regarding potential drinking water risks and, noted as well, concern about ecological effects. To help address these concerns, two comprehensive aquatic ecological risk assessments of atrazine in surface water of North America were conducted and published in the literature. Results from these ecological risk assessments relative to Lake Michigan will be illustrated. To help address the drinking water concern raised in the Special Review, a drinking water exposure assessment was conducted for 27,485 Community Water Systems (CWS) on groundwater and surface water in the 31 major atrazine use states (98 % of annual use) over a 7 year period (1993-1999). Lake Michigan is a source water for drinking water. Approximately 306 CWS provide drinking water for 8.9 million people in the four bordering states. A population-linked drinking water exposure assessment for CWS using Lake Michigan as a raw water source was conducted (1993-1999) and exposure concentrations compared to the Safe Drinking Water Act (SDWA) lifetime Maximum Contaminant Level (MCL) of 3.0 ppb for atrazine. The results of this Lake Michigan specific drinking water exposure assessment will be presented. An update on the status of the atrazine Special Review will also be provided.

The National Weather Service and Its Role in Providing River and Marine Information, Including Forecasts and Warnings

Mark Walton and Bob Dukesherer, National Weather Service Grand Rapids, Michigan

The National Weather Service (NWS) provides weather, hydrologic, and climate forecasts and warnings for the United States, its territories, adjacent waters and ocean areas, for the protection

of life and property, and the enhancement of the national economy. The NWS provides warnings and forecasts of hazardous weather, including thunderstorms, flooding, hurricanes, tornadoes, winter weather, tsunamis, and climate events. The NWS is the United States sole OFFICIAL voice for issuing warnings during life-threatening weather situations.

Regarding Lake Michigan, there are seven NWS offices that issue forecasts and warnings for rivers that are tributary to Lake Michigan, not to mention forecasts and warnings for Lake Michigan itself. The presentation will provide an overview of both the NWS Hydrologic program and the Marine program in and around Lake Michigan. The presentation will include information on how river and marine forecasts are produced as well as how you can access this data via NOAA weather radio, the Internet, and other means.

Lake Michigan Potential Damages Study: Economic Impact of Fluctuating Water Levels on Recreational Boating and Charter Fishing

John Warbach, Planning & Zoning Center
Ed Mahoney, Michigan State University
Chuck Pistis, Michigan Sea Grant Extension

Recreational boating accounts for hundreds of millions of dollars in yearly spending in the states surrounding Lake Michigan. Fluctuations in lake level can restrict boating activity and affect boater spending. Low water can limit the number of usable slips in marinas, reduce the size of boats that marinas can serve, require dredging to provide access, force modification of docks and seawalls, force charter fishing boats to change locations and increase the number of incidents of bottom damage to boats. It can also limit the use of boat launch ramps. High water can cause flooding of launch ramp access roads and parking lots and can create the need for modifications to marina docks. This study looked at spending related to boating in Lake Michigan shoreline counties, how boating activity changed due to recent low water levels and how future changes in water level could affect boat access to Lake Michigan and boater spending. The study was conducted through surveys of boaters, marina operators, charter boat captains and marine dealers. The study also included observation of marina and launch site facilities. In 2001, the study examined all the area surrounding Lake Michigan, in follow-up to a pilot study of five Lake Michigan Counties in 2000. A brief summary of the study method as well as results will be presented.

Lake Michigan Mass Balance Study Update

Glenn J. Warren and Russell G. Kreis, United States Environmental Protection Agency

The Great Lakes receive chemical input from the atmosphere, and a large number of tributaries that flow through multiple jurisdictions. A mass balance approach of monitoring and modeling, leading to load reduction, was established in the 1970's to deal with eutrophication. This is extended to other contaminants in the Lake Michigan Mass Balance Study (LMMBS). Models developed for this study provide the tools to determine the impact of load reduction on the concentrations of contaminants in all media. This presentation centers on two areas: 1) Tributary loads for PCBs, trans-nonachlor and total mercury, as well as tributary average concentrations and in-lake concentrations for these contaminants and, 2) The latest information on atrazine in Lake Michigan. Atrazine is a broadleaf weed herbicide used extensively on corn and sorghum in

the Midwest. The concentrations and loads of atrazine during the LMMBS will be presented. Model results indicate that concentrations are increasing and forecasts suggest that load reductions would be necessary to maintain present concentrations.

Recreational Water Quality Workshop

Richard Whitman, United States Geological Survey

This three-hour working session is aimed at reviewing existing bacteria monitoring programs and considering revisions and recommendations for improvements in water quality monitoring in order to protect swimmers at Lake Michigan bathing beaches. Participants will consider current technology and protocols, recent U.S. EPA recommendations for beach monitoring, and new or developing beach water quality indicator tools. The importance of non-point sources and source tracking will be reviewed. Funding issues and opportunities will be considered. Beach and resource managers, public health officials, environmental scientists, regulators and planners should benefit from participation in this meeting. Participants should be prepared to give a brief review of their local programs and their individual expectations for this meeting.

This meeting will be the beginning of a regional working group to coordinate and improve monitoring of public beaches on Lake Michigan. The *E. coli* Task Force (Indiana/Chicago), Southeast Wisconsin Beach Task Force, Traverse Bay Initiative and Lake Erie Beach Network are examples of local efforts. All of these groups agree that more regional approaches to problems, prospects, networking, and recommendations would be advantageous.

The association that comes from this meeting may evolve into a very active working group that facilitates external funding, consolidates positions and comments, seeks to develop common monitoring and data management protocols, provides members and the public with educational materials, and develops data networks for ready exchange of information, meta-analysis, and tracking. Alternately, the group may merely meet once a year to review current status and progress in beach monitoring policy, criteria, practices, and science and to act as a general forum for exchange of ideas and maintenance of contacts.

Methods for Calculating Damages Due to Extreme Water Levels on Lake Michigan

Daniel L. Zay, DLZ Michigan, Inc
John Warbach, Planning & Zoning Center;
John Hoehn, Michigan State University

DLZ Michigan is assisting the U.S. Army Corps of Engineers on the Lake Michigan Potential Damages Study in five prototype counties along the Lake Michigan shoreline. The study areas include Allegan and Ottawa counties in Michigan and Ozaukee, Sheboygan and Manitowoc counties in Wisconsin. Calculations of potential economic damages from both high and low water scenarios and from bluff erosion are being projected over a 50-year period.

Projected bluff retreat over a 50-year period was used as a starting point in calculating damages due to erosion. The intersection of the projected 50-year bluff lines with existing structures along the bluff was used in this analysis. Low water damage calculation methods include assessing the potential impact of low water on dredging volumes and frequency and potential impacts on shore

protection structures. Methods from this first phase of the study will be discussed and results will be presented.

Estimating flood damages for four rivermouth areas of Saugatuck, Macatawa, Grand River/Spring Lake, and Sheboygan Harbor was also completed. The damage assessments analyzed the potential economic consequences associated with high water levels and the impacts it has on commercial and residential properties. Locations of affected buildings were determined and flood stage damage curves were developed to represent damages at various flood elevations. A summary of the methodologies and results for each of these tasks will be presented.

Future development along the Lake Michigan coastline is also an important consideration in this study. On-site meetings with local planning officials were held to assess the direction of development over the next 50 years along shoreline communities. The implications of future coastal development on potential economic damages will be explored.

Application of the Flood and Erosion Prediction System in Ottawa and Allegan Counties, Michigan

Pete Zuzek and Rob Nairn, Baird & Associates

Baird & Associates have developed, tested and applied a GIS Linked Flood and Erosion Prediction System (FEPS) to over 200 km of Lake Michigan shoreline. The system was developed for the Lake Michigan Potential Damages Study, which was initiated in 1996 by the U.S. Army Corps of Engineers, Detroit District. The presentation will focus on the predictive capabilities of the FEPS, the modeling procedures to quantify the effects of lake level fluctuations on shore erosion and sedimentation, and the GIS tools to map future shoreline position. Specifically, the presentation will consist of three parts: 1) an introduction to the FEPS; 2) the modeling results for the sandy shorelines of Ottawa and northern Allegan Counties; and 3) model estimates for cohesive shore erosion in southern Allegan County.

The FEPS system includes: an extensive geo-spatial coastal database, a graphical user interface, a suite of custom ArcView tools, and links to numerical models. A sample of the model estimates for future shoreline position is provided in Figure 1 below. The presentation will include numerous examples from both Ottawa and Allegan County.

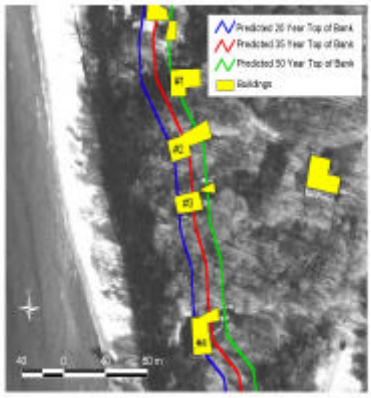

Figure 1 FEPS Estimates of future Top of Bank