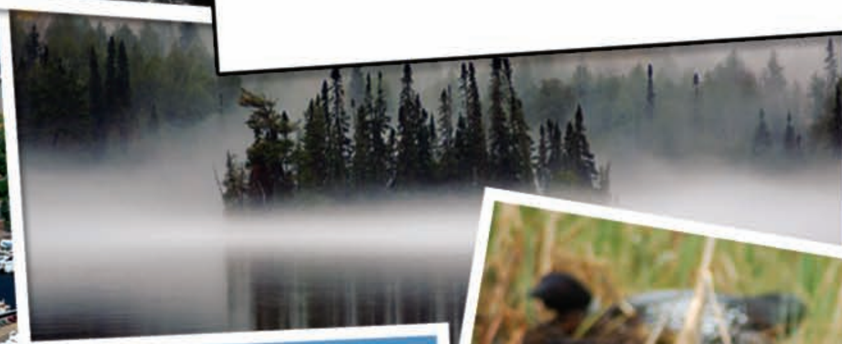
IAGLR 2011
ABSTRACT BOOK

54th Annual Conference on Great Lakes Research

International Association for Great Lakes Research



BIG LAKES - BIG WORLD

IAGLR 2011

Duluth, Minnesota

Monday, May 30 - Friday, June 3, 2011

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ABBOTT, A.N.[1], BERKE, M.A.[1], JOHNSON, T.C.[1], WERNE, J.P.[4], BROWN, E.T.[2], SCHOUTEN, S.[3], and SINNINGHE DAMSTE, J.S.[3], [1]Large Lakes Observatory, Duluth, MN, 55812; [2]Department of Geological Sciences, University of Minnesota Duluth, Duluth, MN, 55812; [3]Netherlands Royal Institute for Sea Research, Texel, Netherlands; [4]Department of Chemistry, University of Minnesota Duluth, Duluth, MN, 55812.
Temperature and Aridity in Tropical East Africa Over the Past 600,000 years: Reconstructions from the Lake Malawi Drill Core.

Tropical heating is the driving force behind global atmospheric circulation and thus is an essential component to our understanding of climate dynamics through time. We present a record of temperature and aridity from Lake Malawi, the southern-most of the large East African Rift lakes, which extends from 9 to 14 °S. The temperature record is based on TEX86 (TetraEther indeX of tetraethers with 86 carbon atoms) analyses on a drill core from the central basin of the lake, which provides a new record from 39 to 380 m burial depth, extending to approximately 600kyr BP. Average lake surface temperature during the past 600kyr was ~25.5°C. When compared to earlier studies, the range of temperatures over the most recent glacial-interglacial transition (MIS 2 to 1) exceeds that of any time earlier in this ~ 600kyr record. No consistent relationship exists between temperature and aridity as indicated by Ca (calcite) abundance in the sediments. Temperature and aridity changes undoubtedly impacted ecosystem dynamics and hominin migration on the East African landscape, at least in the vicinity of Lake Malawi, over the past 600,000 years. The regional extent of this climate history cannot be ascertained until comparable records are recovered through drilling the other great lakes of the East African Rift Valley. *Keywords: Paleolimnology, TEX86, Africa, Lake Malawi.*

ABEL, E.J.[1], COHEN, A.S.[1], and BROWN, E.T.[1], [1]1040 E 4th St., Tucson, AZ, 85721; [2]1040 E 4th St., Tucson, AZ, 85721; [3]2205 E. 5th St, Duluth, MN, 55812. **Exploration of Lake Malawi Sediments Through X-Radiographic Imagery.**

X-radiography provides a non-destructive alternative scanning technique, which can aid in the exploration of sedimentary structures, lithological changes, and bioturbation within a sediment core. When coupled with optical images and scanning XRF data, correlations can be made in order to identify small scale sedimentary variability throughout the core, particularly for features that may not be evident on the sectioned core face. A combination of x-radiography, optical images, and XRF data was used to improve the sedimentological interpretations of drill cores MAL05-1B, MAL05-1C, and MAL05-2A, collected from three separate drill sites in Lake Malawi as part of the Lake Malawi Drilling Project. Cores 1B and 1C were continuously scanned at 0.5mm and 2A was continuously scanned at 0.2mm resolution. X-radiographs were correlated to the optical images and the XRF data and any apparent sedimentological feature was annotated. Preliminary data shows evidence of possible paleosols in core 1B and 1C that can be correlated to Ca abundance peaks in the scanning XRF data. Core 2A contains microlaminations intermittently spaced throughout the 38m core, indicative of meromictic lake conditions through these intervals. The MAL05 x-radiographs provide

an additional method for improving our regional paleoclimatic interpretations.
Keywords: Sediments, Lake Malawi, Paleolimnology.

ABOU, S.C., University of Minnesota Duluth, 1305 Ordean Court, Duluth, MN, 55812, US. **Assessment of the safety of Marine Environment Incorporating Waste Heterogeneity and Data Uncertainty.**

Marine environment is a very complex heterogeneous environment and as such it presents many modeling challenges. Attempts to model these complexities generally involve the use of large numbers of spatially dependent parameters that cannot be properly characterized due to data uncertainty. In this study we use a hybrid approach, which couples a simplified microbial degradation model with a stochastic hydrological and contaminant transport model. This approach provides a framework for incorporating the complex effects of spatial heterogeneity within the marine environment in a simplified manner, along with other key variables. Moreover, a methodology for handling data uncertainty is integrated into the model structure. A subjective qualitative approach has been proposed to overcome the limitations of the definitive logic used by the decision trees in risk assessment practices and the demand for contextual data imposed by rigorous quantitative methods. To demonstrate its use, illustrative examples are presented taking into account effects of data uncertainty on water quality assessment. Uncertainty estimates corresponding to measured water quality data can contribute to improved monitoring design, decision-making, model application, and regulatory formulation.
Keywords: Risk assessment, Assessments, Model studies.

AHMED, S. and TROY, C.D., 550 Stadium Mall Drive, West Lafayette, IN, 47907.
Analysis of internal Poincare wave structure in Lake Michigan.

Near-inertial internal Poincare waves are one of the dominant responses of Lake Michigan due to basin-wide wind forcing. Poincare waves are basin scale waves with near (super)-inertial frequency and an associated ubiquitous influence on currents and temperatures in the Great Lakes during the stratified period. While previous work has been successful in highlighting the radial variability and modal structure associated with these modes in idealized, flat-bottomed, circular basins, the applicability of these models to Lake Michigan is questionable because of the lake's complex bathymetry. To address the role played by actual bathymetry, numerical simulations are carried out using the 3D hydrodynamic model SUNTANS. Idealized, short-duration wind forcing is applied to generate the dominant Poincare response of the basin. In addition to highlighting currents and thermal variability induced by the waves, the associated distributions of cross-thermocline velocity shear and bottom stress are also investigated. Field data from various Lake Michigan field experiments are also compared with the numerical results.
Keywords: Hydrodynamic model, Lake Michigan.

AHRENSTORFF, T.D.[1], JENSEN, O.P.[2], WEIDEL, B.C.[3], MENDSAIKHAN, B.[4], and HRABIK, T.R.[1], [1]207 Swenson Science Building, 1035 Kirby Drive, Duluth, MN, 55812; [2]71 Dudley Road, New Brunswick, NJ, 08901; [3]17 Lake Street, Oswego, NY, 13126; [4]Baruun-Selbe 13, Ulaanbaatar, 211238, Mongolia. **Abundance, spatial distribution, and diet of the endangered Hovsgol grayling (*Thymallus nigrescens*) in Lake Hovsgol, Mongolia.**

Understanding a species' spatial distribution, behavior, and ecological interactions, is important for designing conservation strategies for endangered species and also for providing conservation benchmarks to quantify future effects of environmental changes. The Hovsgol grayling is an endangered species endemic to Lake Hovsgol, Mongolia, which is in an area undergoing rapid climate and land use changes. We used hydroacoustics, gillnetting, zooplankton sampling, and diet analysis to characterize density, spatial distribution, prey availability, and diets of Hovsgol grayling. Grayling densities averaged 34.2 #/ha, which is nearly 6 times lower than fish densities in Lake Superior and 15-25 times lower than Lakes Michigan and Ontario. We observed diel vertical migrations of Hovsgol grayling and zooplankton prey. Juvenile grayling fed primarily upon zooplankton while adults fed more heavily on benthic organisms. Because this is the first quantitative survey of Hovsgol grayling, it is not clear whether the low population density reflects a decline in abundance or the natural consequence of low ecosystem productivity. These results provide information for properly implementing conservation management and monitoring strategies for Hovsgol grayling, and a baseline for interpreting the effects of future environmental change. *Keywords: Fish behavior, Fish, Hydroacoustics.*

ALI, K.A., WITTER, D.L., and ORTIZ, J.D., 221 McGilvrey Hall, Department of Geology, Kent State University, Kent, OH, 44242. **Monitoring Cyanobacteria in the Western Basin of Lake Erie Using MERIS Satellite Data.**

The existence of algal blooms of cyanobacteria in Lake Erie has been documented and these algal species are known to produce toxic substances that are detrimental to the lake's biodiversity. The early detection of harmful algal blooms in the Western Basin of Lake Erie (WBLE) requires a more efficient and accurate monitoring tool. In summer of 2009 and 2010, a suite of measurements and water samples were collected from 18 locations around the WBLE using the Ohio State University Stone Laboratory R/V Gibraltar III. Remote sensing provides synoptic view of the entire WBLE at high temporal coverage and this allows resource managers to effectively map and monitor algal bloom development, near real time. Various remote sensing algorithms have used chlorophyll a and phycocyanin as proxies to detect cyanobacteria, remotely. The MERIS onboard ENVISAT has high spectral resolution of 15 channels (400 to 900 nm), high radiometric sensitivity with 10 nm band width and full spatial resolution (300 m). These settings make the sensor ideal for detecting absorption peaks and fluorescence signals and thus quantifying the distributions of phytoplankton in turbid waters, such as the WBLE. Application of satellite algorithms using MERIS bands accounted for up to 62% and 90%

of the chlorophyll a and phycocyanin variability in the WBLE, respectively.
Keywords: Satellite technology, Lake Erie, Biogeochemistry.

ALLAN, J.D.[1], SMITH, S.D.P.[1], MCINTYRE, P.B.[2], HALPERN, B.[3], BOYER, G.L.[4], BUCHSBAUM, A.[5], BURTON, A.[1], CAMPBELL, L.M.[6], CHADDERTON, L.[7], CIBOROWSKI, J.J.[8], DORAN, P.[7], EDER, T.[9], INFANTE, D.[10], JOHNSON, L.B.[11], LODGE, D.[12], READ, J.[13], RUTHERFORD, E.S.[14], SOWA, S.[7], STEINMAN, A.D.[15], JOSEPH, C.[1], BIEL, R.[1], and OLSON, J.[1], [1]School of Natural Resources & Environment, University of Michigan, Ann Arbor, MI, 48109; [2]Center for Limnology, University of Wisconsin, Madison, WI, 53706-1413; [3]National Center for Ecological Analysis and Synthesis, Santa Barbara, CA, 93101; [4]College of Environmental Science and Forestry, State University of New York, Syracuse, NY, 13210; [5]National Wildlife Federation, Ann Arbor, MI, 48104; [6]Dept. of Biology, Queens University, Kingston, ON; [7]The Nature Conservancy, Lansing, MI, 48906; [8]Dept. of Biological Sciences, University of Windsor, Windsor, ON; [9]Great Lakes Commission, Ann Arbor, MI, 48104; [10]Dept. of Fisheries and Wildlife, Michigan State University, E. Lansing, MI, 48824; [11]Natural Resources Research Institute, University of Minnesota, Duluth, MN, 55811; [12]Dept. of Biological Sciences, University of Notre Dame, South Bend, IN, 46556; [13]Michigan Sea Grant, Ann Arbor, MI, 48109; [14]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 48104; [15]Annis Water Resources Institute, Grand Valley State University, Muskegon, MI, 49441. **Project GLEAM: Mapping Individual Stressors Across the Great Lakes.**

The Great Lakes are subject to a multitude of environmental threats, or stressors, whose impacts vary spatially and across habitat types. The goals of the Great Lakes Environmental Assessment and Mapping Project (GLEAM) are to map the intensity of individual stressors across the Great Lakes, weight them by expected ecological impact, and combine them into a cumulative impact map. We developed a list of some 50 stressors representing every major category of threats to the Great Lakes, ranging from climate change to land-based pollution to exotic species. Data layers were acquired or developed from diverse sources and mapped at the 1-km2 spatial resolution for the five Great Lakes. Where appropriate, stressor influence was propagated beyond its source. This presentation focuses on new maps of individual stressors developed for this project, including tributary delivery of sediments and nutrients, shoreline hardening and development, and recreational boating. By combining this new information with existing basin-wide datasets, GLEAM is generating a comprehensive, spatially-explicit threat assessment for the Great Lakes. The result of this effort will be to provide new perspectives for prioritizing management, restoration, and conservation activities.
Keywords: Environmental effects, Spatial analysis, Spatial distribution.

ALLAN, M.G.[1], HAMILTON, D.P.[1], and TROLLE, D.[2], [1]Centre for Biodiversity and Ecology Research, Department of Biological Sciences,, University of Waikato, Hamilton, New Zealand; [2]The National Environmental Research Institute, Department of Freshwater Ecology,, University of Aarhus, Silkeborg, 8600, Denmark. **Atmospheric**

Correction of Landsat 7 Thermal Imagery for Lake Water Temperature Retrieval and Validation of a Three Dimensional Hydrodynamic Model.

We investigated atmospheric correction of Landsat 7 thermal infrared data using four different sources of atmospheric profile data as an input to a radiative transfer model (MODTRAN v.3.7). The satellite-retrieved water skin temperature in Lake Rotorua (North Island, New Zealand) was validated with 14 images between 2007 and 2009, using a high frequency sensor measuring bulk surface water temperature. The highest accuracy of Landsat 7 temperature prediction was with Radiosonde data as an input into MODTRAN, which gave a root-mean-square-error of 0.36 °C, followed by MODIS Level 2 (0.56 °C), AIRS Level 3 (0.76 °C), and NASA data (1.09 °C). Lake water surface temperature images were then used to validate a three-dimensional hydrodynamic model of nearby Lake Rotoehu. This validation proved that the 3D model reproduced the dominant spatial variations in temperature in the lake including the path of a geothermal inflow and basin-scale thermal patterns. *Keywords: Remote sensing, Lake temperature, Model testing.*

AMOS, M.A.[1], SCHOFIELD, J.A.[1], MURPHY, E.W.[2], BLUME, L.J.[2], MILLER, K.M.[2], TAO, J.T.[2], and BENJAMIN, E.M.[2], [1]Computer Sciences Corporation (CSC), 6101 Stevenson Avenue, Alexandria, VA, 22304; [2]U.S. EPA Great Lakes National Program Office, 77 West Jackson Boulevard, Chicago, IL, 60622. **Uncertainty Analysis for the U.S. EPA's Great Lakes Fish Monitoring and Surveillance Program.**

The USEPA's GLNPO funds & administers the Great Lakes Fish Monitoring & Surveillance Program, which focuses on monitoring trends in contaminant concentrations in fish collected in the Great Lakes' open waters. The program was initially developed as a collaborative effort in the mid-1960s by the USGS & USEPA & underwent changes in administration & focus through the years until it was finally transferred to GLNPO's purview in 2003. The program's success has relied on the dedicated & expert support provided by the field sampling teams from state & federal agencies. The program also has ensured quality & consistency over the years through the use of standardized forms & labels, approved quality documentation such as project & program plans & SOPs, databases designed to track samples & chain of custody, a relational database system that maintains program data, & facilities that store archived homogenate samples. GLNPO conducts focused evaluation of uncertainty & error contribution associated with discrete components of the measurement process & refines the processes accordingly. Without all of these critical moving parts, the reliability of the data could be compromised resulting in inaccurate long-term trends analysis, potential issues in identifying or quantifying emerging contaminants, & misrepresentation of environmental health.
Keywords: Environmental contaminants, Uncertainty, Fish.

ANDERSON, E.J.[1] and SCHWAB, D.J.[2], [1]University of Michigan - CILER, 4840 S. State Rd, Ann Arbor, MI, 48108; [2]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Rd, Ann Arbor, MI, 48108. **Development of a Real-Time Hydrodynamic Model of the Upper St. Lawrence River.**

The St. Lawrence River stretches from the outlet of Lake Ontario to the Atlantic Ocean, providing the only pathway for commercial shipping to the Great Lakes. The Upper St. Lawrence (USL), which lies between Lake Ontario and a hydroelectric dam at Cornwall, Ontario, is a complex waterway with several channels of substantial flow rates and depth. It is home to the 1000 islands area and is a tourist destination in the summer months, providing the primary economic driver for local communities. Large fluctuations in water level along the USL affect access to the waterway, restricting recreational boating and shipping in the river. Therefore, the need to predict the present and future states of the river is necessary to ensure safe boating and to maintain the tourism and shipping industry along the USL. As a result, a 3D hydrodynamic model of the USL has been developed to predict water levels and currents at high resolution (down to 30 m) in real-time. This nowcast/forecast model has been calibrated for a range of steady-state scenarios as well as dynamic simulations, with comparisons and on-going validation via water-level gauges and current meters throughout the river. *Keywords: Hydrodynamic model, St. Lawrence River, Observing systems.*

ANDERSON, J.D. and WU, C.H., Civil and Environmental Engineering, University of Wisconsin-Madison, Madison, WI, 53706, USA. **Extreme Wave Modeling Around the Apostle Islands, Lake Superior.**

Lake Superior hosts some of the most dangerous wave conditions of all the Great Lakes. As these waves traverse the lake, they interact with the 22 Apostle Islands on the northern shores of Wisconsin. Island networks have been documented to host wave conditions favorable for extreme wave creation through eddy currents, diffraction, refraction, and focusing of wave energy. Currently, little information on the wave climate in the Apostle Islands, though they are home to a National Park, a popular fishing destination, and some are inhabited. In this talk, we present a nested set of wave models to examine extreme waves occuring around the Apostle Island with the largest domain encompassing Lake Superior and the second domain encompassing the Apostle Island Network. Specifically high resolution nesting will employ the efficient a non-hydrostatic model to study extreme wave creation in areas of interest. The long-term goal is to develp a warning system to provide real-time (extreme or freak) wave information for the Apostle Island. *Keywords: Waves, Atmosphere-lake interaction.*

ANDRASO, G.M. and GANGER, M.T., Gannon University, 109 University Square, Erie, PA, 16541. **Factors Influencing Size-Selective Predation by Round Gobies (*Neogobius melanostomus*) on Dreissenid Mussels.**

Predation by round gobies (*Neogobius melanostomus*) on dreissenid mussels (*Dreissena polymorpha* and *D. bugensis*) has received considerable attention. Field work conducted in 2007 in Presque Isle Bay, Lake Erie revealed that dreissenids composed 95% of food items consumed by round gobies. Dreissenids between 8 and 11 mm were most important to three size classes of round gobies. Comparisons of maximum size of dreissenids recovered from round gobies, maximum size of dreissenids able to fit into the mouths of round gobies, and preference of round gobies for different sizes of dreissenids indicate that round gobies eat mussels near the size they are capable of fitting into their mouths, but generally prefer mussels that are considerably smaller. Ongoing work in our laboratory suggests that small (< 70 mm TL) round gobies may prefer dreissenids smaller than they are capable of consuming because they do not possess the pharyngeal dentition necessary to crush larger dreissenids. Larger (> 70 mm) round gobies may prefer mussels smaller than they are capable of consuming because large mussels are not readily accessible, forces required to remove and crush mussels increase exponentially with mussel length, and wear of pharyngeal teeth reduces crushing ability as round gobies age.
Keywords: Round goby, Dreissena, Predation.

ANDVIK, R.T.[1], SLOSS, B.L.[2], VANDEHEY, J.A.[3], SUTTON, T.M.[4], HANSEN, S.[5], and CLARAMUNT, R.M.[6], [1]University of Wisconsin-Stevens Point 800 Reserve Street, Stevens Point, WI, 54481; [2]United States Geological Survey WI Cooperative Fisheries Reseach Unit, 800 Reserve Street, Stevens Point, WI, 54481; [3]Department of Wildlife and Fisheries Sciences, South Dakota State University NPB Lab 138 Box 2140B, Brookings, SD, 57007; [4]School of Ocean Sciences University of Alaska-Fairbanks 1W02 Arctic Health Research Bldg PO 757220, Fairbanks, AK, 99775; [5]Wisconsin Department of Natural Resources 110 South Neenah Avenue, Sturgeon Bay, WI, 54235; [6]Michigan Department of Natural Resources and Enviroment 96 Grant Street, Charlevoix, MI, 49720. **Proportional Stock Harvest of the Lake Whitefish Commercial Fishery in Lake Michigan.**

Six genetic stocks of lake whitefish *Coregonus clupeaformis* have been identified in Lake Michigan, providing a framework for stock based management. A better understanding of proportional stock harvest is required to implement new harvest policies. The objective of this research was to determine if differential harvest of lake whitefish stocks in the Lake Michigan commercial catch occurred by total proportion, spatial location, or season. Samples (*n*=150/site) were collected during spring, summer and fall of 2009 and 2010 from two seasonal locations and from six random landing sites throughout Lake Michigan. Samples were genotyped at 11 microsatellite loci. Genetic mixed stock analysis of the commercial harvest was performed with chi-squared tests to determine differences between samples. At any given location and season, a minimum of 4 stocks contributed to the harvest. Differences occurred for both 2009 and 2010 among the total (all samples) contribution of each stock and both spatial and seasonal stock

composition. Furthermore, the location of harvest failed to provide an accurate prediction of the stock composition of commercial harvest. By providing a more accurate means of estimating stock contribution to the fishery, these findings will aid in more efficient management of Lake Michigan's commercial harvest. *Keywords: Genetics, Fish management, Lake Michigan.*

ANSTEAD, A.M.[1], GRIESMER, D.[2], PAUER, J.J.[1], KREIS, R.G.[3], and DOLAN, D.M.[4], [1]ICF International, USEPA Large Lakes Research Station, Grosse Ile, MI, 48138; [2]CSC Corporation, USEPA Large Lakes Research Station, Grosse Ile, MI, 48138; [3]U.S. Environmental Protection Agency, Office of Research and Development, NHEERL, MED, Large Lakes and Rivers Forecasting Research Branch, Large Lakes Research Station, Grosse Ile, MI, 48138; [4]University of Wisconsin - Green Bay, 2420 Nicolet Drive, Green Bay, WI, 54311-7001. **Phosphorus Loading Trends in Lake Michigan: A Historic Surprise.**

Total phosphorus (TP) loads to the Great Lakes have been of interest to researchers since the 1960s. The International Joint Commission (IJC) was the primary source of Great Lakes TP loading data during the 1970's and 1980's when the IJC released annual reports detailing Great Lakes phosphorus loadings. We compiled data from many sources to stitch together a 36-year (1972-2008) loading history for Lake Michigan. The load compilation revealed several interesting observations, with the most striking being that atmospheric TP loads increased 75%, followed by a 90% decrease over the 1978-1981 time period. This decrease in atmospheric TP loads and subsequent total TP loads was of interest because Lake Michigan went from non-compliance in 1980 to compliance with the Great Lakes Water Quality Agreement in 1981. This raises the question whether the decline in TP loading was due to remedial programs or change/improvement of analytical methods to estimate the atmospheric TP loads, or a combination of both. Using the literature, an investigation into the methods used to estimate atmospheric TP loads was conducted. We will present a TP loading history compiled from available data sources, give possible explanations of observed variations, and construct a reasonable TP loading history. This abstract does not necessarily reflect EPA policy. *Keywords: Eutrophication, Nutrients, Lake Michigan.*

APFELBAUM, S.I., 17921 Smith Road, PO Box 256, Brodhead, WI, 53520, US. **Multi-Spectral Aerial Imagery for Near Shore Land Use.**

Multi-Spectral Aerial Imagery for Near Shore Land Use - The integration of ecological and geospatial data provides capability for both analysis and mission planning and in support of land use planning projects. High-resolution aerial imagery services specifically designed to make mapping and analysis of natural and environmental resources more powerful and cost-effective by adapting military reconnaissance technology that eliminates ground survey control and manual processing. This high quality data supports conservation, ecosystem restoration, water quality, land management and ecological research projects. With resolutions as fine as 2 inches of

ground distance per image pixel, and automated image-matching software with pre-existing digital ground elevation model data can assign each image a real-world location with a horizontal accuracy of a couple of meters. Applications include testing green infrastructure against traditional and SE Wisconsin watersheds assessments.
Keywords: Lake Michigan, Multi-Spectral Aerial Imagery, Monitoring, Near Shore Land Use, Ecosystems, Geospatial.

ARGYILAN, E.P.[1], AVIS, P.[1], DORIN, W.[1], PELLER, J.R.[1], EBERHARDT, L.[2], GOYNE, T.[2], SCHOER, J.[2], FADEL, L.[3], ROSILLO, L.[3], and DASILVA, A.[4], [1]Indiana University Northwest, Gary, IN, 46403; [2]Valpariso University, Valparaiso, IN, 46383; [3]Ivy Tech Community College, Gary, IN, 46408; [4]Calumet College of Saint Joseph, Whiting, IN, 46394. **Collaborations in Watershed Studies in Northwest Indiana Created through The Great Lakes Innovative Stewardship Through Education Network (GLISTEN).**

The GLISTEN cluster of Northwest Indiana is dedicated to promoting and enhancing the restoration of the Lake Michigan watershed by integrating efforts in education, stewardship, and research. The cluster consists of undergraduate institutions, local environmental non-profits, and environmental consultants. Undergraduate student stewardship liaisons worked closely with the Save the Dunes Conservation Fund to conduct water quality sampling and promote watershed education in the Salt Creek watershed on the southern shore of Lake Michigan. Undergraduate student stewardship liaisons working with the Shirley Heinze Land Trust and the Northwest Indiana Restoration Monitoring Inventory (NIRMI) engaged in vegetation management and monitoring activities focused on ecological restoration of the landscape. During the academic year, student stewardship liaisons used their new knowledge and skills to assist faculty in development of service learning components in Biology, Chemistry, Engineering, and Geoscience courses during fall 2010 and spring 2011. The emphasis on watershed restoration and the preservation of open space for an enhanced quality of life is consistent with the values of the communities of Northwest Indiana and the Calumet region. *Keywords: Watersheds, Education, Lake Michigan, Monitoring.*

ARHONDITSIS, G.B., GUDIMOV, A., RAMIN, M., SHIMODA, Y., WELLEN, C., and PERHAR, G., Department of Physical & Environmental Sciences, University of Toronto, Toronto, ON, M1C 1A4. **Eutrophication Risk Assessment Using Bayesian Inference Techniques.**

The importance of investigating the effects of uncertainty on mathematical model predictions has been highlighted in the modelling literature. The question of model credibility is important because models are used to identify polluters, to direct the use of research dollars, and to determine management strategies that have considerable social and economic implications. Erroneous model outputs and failure to account for uncertainty could produce misleading results and misallocation of limited resources during the costly implementation of environmental management plans. Striving for novel uncertainty analysis tools, we introduce Bayesian calibration of process-based models as a methodological advancement that warrants consideration in aquatic ecosystem research. One of the basic features of the Bayesian approach is the ability to sequentially update beliefs as new knowledge is available, and the consistency with the scientific process of progressive learning and the policy practice of adaptive management. Finally, we illustrate some of the anticipated benefits from the Bayesian calibration framework, well suited for stakeholders and policy makers when making decisions for sustainable environmental management, using as a case-study the Hamilton Harbour; a eutrophic system in Ontario, Canada. *Keywords: Ecosystem modeling, Risk assessment, Water quality.*

ASH, J.L., COHEN, A.S., REINERS, P.W., and DETTMAN, D.L., Unversity of Arizona Department of Geosciences, 1040 E 4th St, Tucson, AZ, 85721. **Ostracode Trace Metal Geochemistry from Lake Tanganyika, Africa: The Application of HR-ICP-MS in Paleotemperature Analysis.**

Lake Tanganyika, Africa's largest rift lake, is influenced by regional land use changes and global climate change. Understanding past variations in the hydrology and water temperature of Lake Tanganyika is critical to understanding its current changes as well as the response of its biota. While recent changes can be observed via instrumental data collection, paleolimnological records must be developed in order to delve farther into the past. We aim with this research to explore variations in trace metal geochemistry of ostracode valves from Lake Tanganyika core LT-98-58M. Trace element compositions of ostracode valves reflect discriminatory element uptake that in turn reflect ambient environmental conditions. Understanding the specific environmental controls on element concentrations and ratios is an area of active research with much attention focusing on Mg/Ca and Sr/Ca ratios and their relationships with temperature and salinity. Here, geochemical analyses of ostracode valve are compared to other existing temperature records to determine how trace metal ratios reflect changes in water temperature and chemistry. We intend this pilot study to facilitate the future use of trace element geochemistry with African ostracodes for paleolimnological reconstruction.
Keywords: Lake Tanganyika, Climate change, Ostracoda, Africa, Geochemistry.

AUSTIN, J.A. and CHENG, P., Large Lakes Observatory, UM Duluth, Duluth, MN, 55812, USA. **An extraordinary upwelling event in Lake Superior during Summer 2010.**

During August 2010, a southwest wind event unprecedented in its strength and duration resulted in a combination of upwelling-favorable circulation and vertical mixing, fundamentally redistributing heat in Lake Superior. The surface waters of the narrow western arm of the lake were almost completely replaced by cooler water from below the thermocline, while sites along the Keweenaw Peninsula and in the southern basin of the lake were inundated with warmer surface water. A mid-lake mooring in the western part of the lake showed a sharp drop in heat content at around the same time, but was too far

offshore for this to be due to coastal upwelling, suggesting that this may have been due to open-water upwelling due to curl in the wind field. Using data from a set of moorings that were deployed in the lake at the time, we consider the balance between vertical wind-driven mixing and lateral circulation for determining the resulting temperature distribution. *Keywords: Water currents, Upwelling, Storm events.*

AXLER, R.P.[1], HOST, G.E.[1], WILL, N.J.[1], HENNECK, J.[1], RUZYCKI, E.M.[1], SJERVEN, G.[1], HAGLEY, C.A.[2], SCHOMBERG, J.[2], CARLSON, T.[3], KLEIST, C.[3], AUSTIN, J.A.[4], DOBIESZ, N.E.[4], HECKY, R.E.[4], ANDERSON, J.[5], TUOMINEN, T.[6], BAUMAN, H.[5], and MAGYAR, J.[5], [1]Natural Resources Research Institute- U. of Minnesota Duluth, 5013 Miller Trunk Highway, Duluth, MN, 55811; [2]Minnesota Sea Grant, U. of Minnesota Duluth, Duluth, MN, 55812; [3]City of Duluth City of Duluth Stormwater Utility, COmfort Systems Garfield Avenue, Duluth, MN, 55802; [4]Large Lakes Observatory, U. of Minnesota Duluth, Duluth, MN, 55812; [5]Minnesota Pollution Control Agency, 520 Lake Ave Suite 400, Duluth, MN, 55802; [6]Western Lake Superior Sanitary District, 2626 Courtland Street, Duluth, MN, 55806. **Weather, Water, and People: Stream, lake, and beach water quality data animations to protect Lake Superior streams and coastal zones.**

Coastal communities across the northern Great Lakes are increasingly facing 'tipping points' - points at which stream trout can no longer survive due to thermal stress, beaches become unswimmable due to E. coli violations, water quality is degraded by nutrient and organic matter inputs, or streams require costly TMDL studies and remediation strategies because they exceed threshold turbidity levels. www.LakeSuperiorStreams.org, www.MinnesotaBeaches.org, and www.GlobalGreatLakes.org use novel, on-line interactive data visualization animations and maps of automated, remote stream and lake water quality data, Beach Advisory bacteria data, and fisheries data to link weather and landuse to the condition of sensitive streams and coastal zones. The tools enable users to pursue independent exploration of the data and downloadable data vignettes created from these interactive tools are being used to inform and educate a variety of public and private sector audiences about how streams "work", how they can be degraded by stormwater from our activities in the watershed, and what actions can be taken by individual homeowners, businesses, contractors, developers, consultants, resource agencies and municipal officials to protect these sensitive waters. *Keywords: Environmental education, Website data visualization, Remote sensing, Lake Superior, Great Lakes tributaries, Water quality.*

AXLER, R.P.[1], HOST, G.E.[1], WILL, N.J.[1], HENNECK, J.[1], RUZYCKI, E.M.[1], SJERVEN, G.[1], HAGLEY, C.A.[2], SCHOMBERG, J.[2], CARLSON, T.[3], KLEIST, C.[3], TUOMINEN, T.[4], ANDERSON, J.[5], WESTERBUR, A.[6], and ANDERSON, K.[7], [1]Natural Resources Research Institute- U. of Minnesota Duluth, 5013 Miller Trunk Highway, Duluth, MN, 55811; [2]Minnesota Sea Grant, U. of Minnesota Duluth, Duluth, MN, 55812; [3]City of Duluth City of Duluth Stormwater Utility, Comfort Systems Garfield Avenue, Duluth, MN, 55802; [4]Western Lake Superior Sanitary District, 2626

Courtland Street, Duluth, MN, 55806; [5]Minnesota Pollution Control Agency, 520 Lake Ave Suite 400, Duluth, MN, 55802; [6]Minnesota's Lake Superior Coastal Program, MN Dept of Natural Resources, Two Harbors, MN; [7]South St. Louis SWCD, 215 North 1st Ave. East, Rm. 301, Duluth, MN, 55802. **LakeSuperiorstreams.org: Making stormwater and stream data come alive for citizens, students, teachers, contractors, resource agencies, decision-makers and scientists.**

Urbanization and rural development are placing pressure on western Lake Superior streams and nearshore zones via increased stormwater runoff. Stream and coastal zone degradation represents a significant social and economic impact to a region whose economy and character are tied to its pristine natural state. The LakeSuperiorStreams.org project uses web-based delivery of real-time stream monitoring data to address issues of sustainability in critical Minnesota watersheds at the headwaters of the Great Lakes. The website delivers intensive flow, temperature, turbidity and conductivity data via a unique interactive data animation tool from five urban trout streams, the St. Louis River, two North Shore Superior tributaries, and a nearshore Lake Superior buoy. Data are incorporated as vignettes into interpretive information, curricula, case studies and a site design toolkit to educate contractors, consultants, developers, students, teachers, homeowners, agencies, decision-makers and scientists about stormwater issues and links to watershed activities. The website averages about 400,000 requests/mo and 100,000 page requests/mo with an estimated 40% from the region and 25% associated with intensive school curricula. *Keywords: Lake Superior, Water quality, Tributaries, Stormwater, Environmental education, Website.*

<u>BADE, D.L.</u>[1], CONROY, J.D.[2], PENNUTO, C.M.[3], CULVER, D.A.[4], KANE, D.D.[5], BURLAKOVA, L.E.[3], KARATAYEV, A.Y.[3], PEREZ-FUENTETAJA, A.[3], KRAMER, J.W.[6], MATISOFF, G.[7], and EDWARDS, W.J.[8], [1]Kent State University, Kent, OH, 44242; [2]Ohio Department of Natural Resources, Hebron, OH; [3]Buffalo State, Buffalo, NY; [4]The Ohio State University, Columbus, OH; [5]Defiance College, Defiance, OH; [6]Heidelberg University, Tiffin, OH; [7]Case Western Reserve University, Cleveland, OH; [8]Niagra University, Lewiston, NY. **Biological phosphorus uptake in Lake Erie's tributaries and offshore sites.**

Continuing issues of eutrophication in Lake Erie, and questions about the influence invasive species (e.g. dreissenid mussels) have on ecosystem dynamics require further exploration into the cycling of phosphorus (P) in this system. We measured two metrics of biological P use by algae and bacteria along multiple transects. These metrics can indicate whether P is limiting to productivity. Two transects included streams (Maumee River and Sandusky River) and extended into the lake, while three other transects focused on nearshore to offshore sites in the Central and Eastern Basin of Lake Erie. There were differences in P use at different sites and times. However, there were no consistent pattern of P use observed along nearshore to offshore transects. Some patterns of changing phosphorus limitation along the river transects were observed. Some of these differences are attributed to changes in nitrogen (N) concentration. For example, when N was low algae were often not limited by P. Overall, there are many sites that did not show conditions of P limitation. This suggests that additional factors, such as N, should be considered for better modeling and management of Lake Erie. *Keywords: Nitrogen, Phosphorus, Algae.*

BAI, X.[1], WANG, J.[2], COLTON, M.C.[2], LIU, Q.[3], and LIU, Y.[3], [1]Cooperative Institute for Limnology and Ecosystems Research, University of Michigan, 4840 S. State Rd., Ann Arbor, MI, 48108; [2]NOAA Great Lakes Environmental Research Laboratory (GLERL), 4840 S. State Rd., Ann Arbor, MI, 48108; [3]National Marine Environmental Forecasting Center, State Oceanic Administration, Beijing, China. **Severe Ice Conditions in the Bohai Sea, China and Mild Ice Conditions in the Great Lakes during the 2009/2010 Winter:Links to El Nino and a Strong Negative Arctic Oscillation.**

This study investigates the causes of severe ice conditions over the Bohai Sea, China and mild ice cover over the North American Great Lakes under the same hemispheric climate patterns during the 2009-2010 winter with a strong negative Arctic Oscillation (AO) and an El Nino event. The main cause of severe ice cover over the Bohai Sea was due to the strong negative AO.The influence of El Nino on the Bohai Sea was not significant. On the contrary, the mild ice conditions in the Great Lakes were mainly caused by the strong El Nino event. Although the negative AO generally produces significant colder surface air temperature (SAT) and heavy ice cover over the Great Lakes, when it coincided with a strong El Nino event during the 2009-2010 winter, the El Nino-induced Pacific-North America (PNA)-like pattern dominated the mid-latitude, and was responsible for the flattening of the ridge-trough system over North America, leading to warmer-than-normal temperatures and mild ice conditions over the Great Lakes.This comparative study revealed that interannual variability of SAT in North America, including the Great Lakes, is effectively influenced by El Nino events via a PNA or PNA-like pattern, while the interannual variability of SAT in northeastern China, including Bohai Sea area, was mainly controlled by AO and SH. *Keywords: Ice, Climates, Great Lakes basin.*

BAILEY, J.F.[1], LINDGREN, B.L.[2], and RADKE, L.M.[3], [1]EcoSuperior, 562 Red River Rd., Thunder Bay, ON, P7B 1H3; [2]Lake Superior Binational Forum, 15165 Spruce Tree Drive, Herbster, WI, 54844; [3]Northland College, 1411 Ellis Ave., Ashland, WI, 54806. **Making it Great, Keeping it Great - Lessons Learned on Superior.**

Lake Superior is faced with many of the same issues which affect the lower Great Lakes. These include chemical contaminants, habitat loss and degradation, areas of concern and developing sustainability. Problems are intensified by new and emerging issues such as a huge increase in proposed mining developments along with severe economic downturn due to industry losses in the forestry sector. For close to 20 years, the Lake Superior Binational Forum representing citizen stakeholders, co-ordinated by EcoSuperior and Northland College, has been at the centre of Lake Superior Binational Program restoration and protection efforts. A detailed review of programs and projects

implemented by these organizations, both successes and failures, reveals useful lessons. Initiatives include a full range of activities from benthic biomonitoring, survey research and pollution prevention to outreach campaigns and community events. Such practical experience on this Great Lakes source watershed is essential information for all organizations striving to achieve future progress in meeting Lakewide Management Plan goals. *Keywords: Ecosystem health, Public education, Pollutants.*

BAILEY, S.A., Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences, Burlington, ON, L7R 4A6. **Proposal to Utilize Ballast Water Exchange in Combination with a Ballast Water Management System to Achieve an Enhanced Level of Protection.**

Invasion success is primarily related to three factors: propagule pressure, environmental conditions, and biological interactions. Ballast water exchange (BWE) is particularly effective for reducing invasion risk to the Great Lakes through the introduction of a salinity barrier. In-tank sampling of 16 ships arriving to the Great Lakes indicates that the total abundance of invertebrates after BWE is typically around 2500 individuals per 1000L. However, the "effective invasion risk" for low salinity ports is typically much lower, with abundance of invertebrates with high probability for survival in freshwater being much lower: median 1.0 individuals per 1000L. As a result, BWE can frequently provide the same level of protection for freshwater recipient ports as a ballast water managements system (BWMS) which meets the IMO D-2 standard (<10 individuals per 1000L). However, utilization of a BWMS may no longer introduce an environmental salinity barrier. I will present theory and preliminary data behind a proposal for a combination approach, utilizing a BWMS together with BWE, to provide robust protection for the Great Lakes. *Keywords: Zooplankton, Invasive species, Ballast.*

BAKER, D.B., KRAMER, J.W., EWING, D.E., MERRYFIELD, B.J., CONFESOR, R.B., and RICHARDS, R.P., Heidelberg University, 310 East Market Street, Tiffin, OH, 44883. **A Comparison of Mixing Zones between Storm and Base Flows for Major Ions and Dissolved and Particulate Nutrients: A Case Study in the Lower Maumee River, Maumee Bay and Nearshore Waters of the Western Basin of Lake Erie.**

Landscape derived nutrients and sediments are delivered to river mouth and adjacent ecosystems in pulses associated with storm runoff events. Not only does the riverine chemistry differ greatly between storm and base flows, but so too does the location where lake water mixes with riverine water. In April 2010, we initiated daily sampling during a runoff event at a transect/grid of twelve stations extending from 7 miles upstream from the mouth of the Maumee River to 7 miles into the western basin along the shipping channel. Here we compare the concentration profiles of conservative parameters, dissolved nutrients and particulate pollutants during the flood event with collections at the same transect points during low flow conditions. Under low flow conditions, mixing between the riverine and lake water occurred at the river mouth inside of Maumee Bay while during high flows partial mixing was evident at the two most lake-ward stations. Dissolved nutrient concentrations (phosphorus, nitrate and silica) were much higher during the storm event than during base flows. Particulate pollutants were also higher during the runoff event but began settling out of the water column upon entering the lower river. Studies of pollutant transport through- and processing within - river mouth ecosystems should include high flow periods. *Keywords: Coastal ecosystems, Sediment transport, Coastal processes, Lagrangian analyses, Nutrients, Maumee River.*

BAKER, E.[1], STURTEVANT, R.A.[2], RUTHERFORD, E.S.[2], FUSARO, A.[2], and ALLAN, J.D.[1], [1]School of Natural Resources and Environment, University of Michigan, Ann Arbor, MI, 48109; [2]NOAA Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108. **GLANSIS Watchlist.**

Invasive species are gaining greater attention in recent years, including that many are in the Great Lakes and more may come. Prevention is the best measure to take against invasive species, and for successful prevention, information is needed. Searching literature for that purpose resulted in a list of 72-74 invertebrate, fish, and plant species that could potentially invade the Great Lakes. The choices were based on whether they came from a known donor region, whether they could survive transport or be brought in high numbers or frequency, whether their climate matched the Great Lakes, and whether they had a history of successful invasion. More research is needed, including about whether current ballast water regulations have tightened sufficiently to reduce the potential impact of species introduced by that means, and about specific groups of species, including insects, that were not widely researched for invasion potential. *Keywords: Invasive species, Biological invasions, Outreach.*

BAKER, K.N., Dept. of Biological and Environmental Sciences, Heidelberg University, Tiffin, OH, 44883. **Shallow-water Abundances of Round Gobies (*Neogobius melanostomus*) Within the Western Basin of Lake Erie, 1996-2010.**

Between 1996 and 2010, I conducted 149 shallow-water, scuba-based transect surveys of round gobies and dreissenid mussels within the western basin of Lake Erie. Repeated surveys during eleven sampling years at six pairs of established dive locations by Kelley's Island, South Bass Island and West Sister Island (as supplemented by a small number of surveys at Crib, Cone, Locust, Niagara, Round and Toussaint Reefs) provide insight into patterns of goby abundance at shallow-water locations within the western basin. From 1997 to 1999-2000, the round goby increased from exceptionally rare to becoming the dominant (and commonly only) bottom-dwelling fish observed, with densities between 10.2-14.2 fish/m^2. Thereafter, abundances steadily decreased at all island sites to about 50% of peak abundance in 2005. In 2007, however, goby numbers at the island sites recovered much of their previous high densities, although the 2010 survey again found their numbers down nearer to 2005 levels. My survey methods monitored goby abundance by size class, and analysis of size distributions of fish over the 11 years of this study suggest that, fluctuations in numbers notwithstanding, the species has established a long-term, viable presence within the western basin. *Keywords: Round goby, Invasive species, Fish populations.*

BALCER, M.D.[1] and CANGELOSI, A.A.[2], [1]University of Wisconsin - Superior, PO Box 2000, Superior, WI, 54880; [2]Northeast-Midwest Institute, 50 F Street NW, Suite 950, Washington, DC, 20001. **Evaluating the Effectiveness of Ballast Water Treatment on Freshwater Zooplankton: Looking for the Needle in the Haystack.**

In order to slow the spread of aquatic invasive species, performance guidelines for ballast water treatment systems have been proposed by the International Maritime Organization (IMO), U.S. Coast Guard and many individual states. These guidelines include target densities for live organisms in various size classes that should not be exceeded. In freshwater ecosystems the "greater than 50 microns in minimum dimension" size class is dominated by rotifers and crustacean zooplankton. Scientists with the Great Ships Initiative (GSI) have been conducting experiments at a land-based test facility in Superior, WI to develop methods to evaluate the effectiveness of candidate treatment systems on this size category of organisms. Our studies have shown that the species composition and size distribution of zooplankton in freshwater ecosystems mandates different analysis techniques than those used for marine organisms. Determination of the density of live zooplankton in treated samples becomes even more complicated when evaluating treatment systems that do not remove phytoplankton or dead zooplankton from the samples. We will present data comparing our analysis methods to those of other labs and documenting the precision of our methods in determining compliance of different treatment systems. *Keywords: Ballast, Zooplankton, Assessments.*

BALLARD, K.M.[1], HART, D.A.[2], WU, C.H.[3], and CLARK, G.R.[4], [1]University of Wisconsin-Madison, 1975 Willow Drive, Room 202, Madison, WI, 53706; [2]University of Wisconsin Sea Grant Institute, 1975 Willow Drive, Room 201, Madison, WI, 53706; [3]1269d Engineering Hall, 1415 Engineering Dr, Madison, WI, 53706; [4]246 Hawkes Hall, Superior, WI, 54880. **Learning How to Become More Resilient to Coastal Hazards on the Great Lakes: Inquiry-Based Lessons Integrating Open Water Observations and Local Government Spatial Data.**

The cornerstone of the educational efforts for the Great Lakes Observing System is a web portal developed by Michigan Sea Grant and partners titled "Teaching with Great Lakes Data." It includes lesson plans that leverage Great Lakes data to teach about dead zones, finding fish, climate and weather patterns, and storms. The Great Lakes Sea Grant Network is currently working to enhance this curriculum. As a part of this effort, Wisconsin Sea Grant created two new inquiry-based lessons that integrate spatial data about storm events and physical characteristics to better understand the nature of coastal hazards. The first lesson compares several forms of observation of wind and waves (buoy readings, webcams, etc.) with output from nowcast/forecast models. This allows students to question the assumptions behind models. The second lesson relates observations about waves and water levels at specific locations to topography, bathymetry, orthophotography, shore features, and parcels. This allows students to explore how the physical form of the coast affects waves, how water levels influence flooding and erosion, and how coastal hazards impact property. This presentation examines how scientists, geospatial technology specialists, teachers, and students can collaborate to promote resilience to coastal hazards in Great Lakes communities. *Keywords: GIS, Observing systems, Education.*

BALLARD, M.M.[1], ROBERTSON, D.M.[2], and MAYER, A.S.[1], [1]Michigan Technological University, Department of Civil and Environmental Engineering, 1400 Townsend Drive, Houghton, MI, 49931; [2]U.S. Geological Survey, Wisconsin Water Science Center, 8505 Research Way, Middleton, WI, 53562. **Forecasting Future Phosphorus Loading in the Great Lakes Region from Changing Land-Derived Nutrient Inputs.**

Phosphorus (P) is a critical element in the eutrophication of the freshwater ecosystems, including the Great Lakes. Land-derived P from high yielding sources such as agriculture and urbanization affect eutrophication on various scales (e.g. specific bays to all of Lake Erie). SPARROW (SPAtially Referenced Regression On Watershed attributes), is a spatially explicit watershed model, that has been used to understand linkages between land-derived sources and nutrients transport in the Great Lakes Region. Highest P loads were from areas with intense agriculture and large point sources. Currently, the Great Lakes region is experiencing changing patterns in urbanization and agriculture that will affect future P loading. To forecast future changes in P loading, models are being developed that relate changes in land use to changes in nutrient sources, including relationships between row crop acreage and fertilizer intensity and urban land use and point source intensity. The information will be used as input into HydroSPARROW, a forecasting tool developed that enables SPARROW to simulate the effects of various land and climate scenarios. Consequently, this work will focus on understanding the effects of how specific agriculture and urbanization activities affect P loading. *Keywords: Phosphorus, Land use, Watersheds, Great Lakes, Nutrients.*

BARBIERO, R.P.[1] and WARREN, G.J.[2], [1]CSC Inc. and Loyola University Chicago, 1359 W. Elmdale Ave #2, Chicago, IL, 60660; [2]USEPA Great Lakes National Program Office, 77 W. Jackson Boulevard, Chicago, IL, 60604. **Rotifer Communities in the Laurentian Great Lakes, 1983-2006.**

Rotifer communities have been monitored in all five Great Lakes by the US EPA between 1983 and 2006. During this time, most (>80%) individuals encountered were drawn from the following taxa: *Conochilus unicornis*, *Polyarthra vulgaris*, *Keratella cochlearis*, *Kellicottia longispina*, *Keratella crassa*, *Synchaeta* spp., *Polyarthra major*, *Ploesoma truncatum*, *Keratella earlinae* and *Keratella quadrata*. While several species were restricted to regions of higher eutrophication, notably the western basin of Lake Erie, most taxa were widely distributed, differing in relative dominance rather than presence or absence. In general, community composition was strongly associated with trophic state, with the four most common genera exhibiting the following preferences, in order of decreasing trophic state: *Polyarthra*, *Keratella*, *Conochilus* and *Kellicottia*. Shifts in community composition were seen in Lake Huron and Lake Michigan in response to recent oligotrophication, while in Lake Ontario, the appearance of the exotic predatory *Cercopagis pengoi* was associated with dramatic reductions in *Polyarthra*. *Keywords: Zooplankton, Trophic level, Cercopagis pengoi.*

BARRETT, C.H.[1], TAILLON, K.[2], KIM, K.[2], MILANI, D.[2], CHAMBERS, M.[2], MCCHRISTIE, M.[3], HENNING, M.H.[4], FUCHSMAN, P.[5], and ANTUNES, P.M.C.[1], [1]Algoma University, Sault Ste. Marie, ON, P6A 2G4; [2]Environment Canada, Toronto, ON, M3H 5T4; [3]Ministry of the Environment, Thunder Bay, ON, P7E 6S7; [4]Environ, Portland, ME, 04101; [5]Environ, Cleveland, OH, 44021. **Use of Multiple Lines of Evidence to Support Sediment Remediation and Management Decisions for the St. Marys River Area of Concern.**

The St. Marys River connects Lake Superior and Lake Huron and is often referred to as the "Hub of the Great Lakes." Since the early 1900s the river has received industrial and municipal wastewater, which has resulted in sediment contamination with petroleum hydrocarbons, polycyclic aromatic hydrocarbons, oils/grease, and metals such as chromium, iron, and zinc. Because of the extensive contamination, a portion of the St. Marys River was designated as an Area of Concern under Annex 2 of the 1987 Canada-US Great Lakes Water Quality Agreement. The agreement requires the development of a Remedial Action Plan (RAP). Under the RAP, science-based evidence is being collected in support of the Canada-Ontario Decision-Making Framework for Assessment of Great Lakes Contaminated Sediment. This includes an assessment of sediment toxicity, benthic community structure, pore water chemistry, surficial and at-depth sediment chemistry, and modeling of sediment transport and fate under various conditions. The results of these studies, as well as a Conceptual Site Model that schematically illustrates contaminant sources, migration pathways, and potential impacts will be presented and discussed in the context of developing a sediment management plan for the St. Marys River. *Keywords: Sediments, St. Marys River, Remediation, Lake Superior, Management.*

BARTON, D.R.[1] and HOWELL, E.T.[2], [1]Department of Biology, University of Waterloo, Waterloo, ON, N2L 3G1; [2]Environmental Monitoring and Reporting Branch, Ontario Ministry of the Environment, Toronto, ON, M9P 3V6. **Is benthic algal accumulation in SE Lake Huron facilitated by *Dreissena* or lack of grazers?**

The recent increases in nuisance algae on southeastern Lake Huron beaches do not appear to reflect increased nutrient inputs. We have begun investigating alternative hypotheses that proliferation of benthic algae may be favored by the presence of *Dreissena* spp., or a reduction in the abundance of grazers as a result of predation by round gobies. We sampled benthic algae and invertebrates at depths of 1 - 20 m in the vicinity of Kincardine, Ontario during July 2010. Densities of Chara decreased, but

Dreissena and periphytic algae increased, with increasing depth. Few mussels were found at depths <4 m, and estimates of density were extremely variable in deeper water. Small mussels (shell length <15 mm) were very rare at all depths. Other invertebrates were predominantly Chironomidae and Oligochaeta; larger grazers were very rare. Round gobies were abundant throughout the study area. Our results suggest that grazing pressure on benthic algae is low, and ther is very little recruitment of *Dreissena* spp. Further change appears imminent. *Keywords: Dreissena, Nuisance algae, Benthos, Lake Huron.*

BAYER, T.K., BURNS, C.W., and SCHALLENBERG, M., University of Otago, Department of Zoology, PO Box 56, Dunedin, New Zealand. **Effects of climate change on large, oligotrophic lakes in New Zealand.**

For the Central Otago Region of New Zealand, downscaled climate models predict a 2K increase in air temperature by 2090, less annual rainfall and stronger westerly winds. The lakes in this area also face increasing pressure from land use development. We present projections on the future physical and ecological state of two large, oligotrophic lakes, using DYRESM-CAEDYM modelling combined with conclusions from experimental and field data: Because of severe nutrient limitation climate change is unlikely to result in increased algal biomass in summer unless land use changes cause nutrient enrichment. A shallower mixed layer and nutrient enrichment could reduce the importance of picocyanobacteria, which in the past have accounted for more than half of phytoplankton biomass, and favour smaller centric diatoms. Lake Wanaka has already undergone a change in phytoplankton community structure towards Cyclotella. This diatom seems to produce copious amounts of extracellular polysaccharides, facilitating the formation of macroaggregates which alter lake ecology and interfere with fishing. Combining physiological experiments, dynamic modelling of the physical environment and comparative study of multiple lakes assists prediction of future limnological outcomes, because each of these approaches provides useful and complementary information. *Keywords: Phytoplankton, Climate change, Bioindicators.*

BEALL, B.F.N., MCKAY, R.M., and BULLERJAHN, G.S., Department of Biological Sciences, Bowling Green State University, Bowling Green, OH, 43403. **Phytoplankton Through Different Eyes: Flow Cytometric Analysis of Phytoplankton Communities in Lake Superior.**

Primary production in Lake Superior is dominated by small phytoplankton, yet most analyses rely on size-fractionated chlorophyll to estimate biomass and abundance. We collected phytoplankton samples from western Lake Superior from May through October 2010 and analyzed the abundance and size structure of the small phytoplankton community using flow cytometry. Depth and temporal trends were observed for picocyanobacteria and two size-based groups of eukaryotic phytoplankton. In May, eukaryotic phytoplankton between ~6 μm and ~20 μm were dominant in the phytoplankton community. Later in the summer, however, phycoerythrin-rich picocyanobacteria and small eukaryotic phytoplankton were numerically dominant. The

flow cytometric analysis also estimates phytoplankton abundance and biomass independent of chlorophyll a concentrations and we observed some divergence between biomass estimates from the two methods. These observations serve as a baseline of future studies of the phytoplankton community in Lake Superior and highlight the need to incorporate new tools for the study of microorganisms in the Great Lakes.
Keywords: Phytoplankton, Flow cytometry, Lake Superior, Distribution patterns.

BECHLE, A.J.[1], LIU, P.C.[2], ANDERSON, J.D.[1], and WU, C.H.[1], [1]University of Wisconsin-Madison, 1415 Engineering Drive Room 1269, Madison, WI, 53706; [2]NOAA Great Lakes Environmental Research Laboratory, 2205 Commonwealth Blvd, Ann Arbor, MI, 48105. **Monitoring and Characterization of Freak waves in Lake Superior.**

Freak waves are unexpected and unusually large waves with a wave height that exceeds twice the significant wave height. At Lake Superior's Apostle Islands National Lakeshore, wave interaction with the islands and the mainland sea caves create complex wave patterns and potential freak wave activity. To characterize the freak wave climate at the sea caves, coastal waters were monitored with both a stereo imaging system and a pressure transducer. Through the use of multiple cameras, stereo imaging remotely captures 3D maps of the water surface which are used to spatially characterize the freak waves. Unique properties of 3D freak waves such as steepness, vertical and horizontal asymmetry, and spectral bandwith are examined to lend insight into the physics and life-cycle of freak waves. A near-surface pressure sensor provides a continuous wave record which reveals numerous events that fit the freak wave criteria. Wind and wave conditions during and preceding freak wave events are analyzed to identify potential causes of freak waves at the sea caves. *Keywords: Waves, Remote sensing, Lake Superior.*

BECK, J.[1] and EDSTROM, J.E.[2], [1]United States Environmental Protection Agency, 77 W. Jackson Blvd., 17th Floor, Chicago, IL, 60602; [2]Environmental Consulting & Technology, Inc., 125 S. Wacker Dr., Suite 300, Chicago, IL, 60606. **Enhancing Opportunities for Interactive Watershed Management in the Lake Michigan basin.**

The Lake Michigan Lakewide Management Plan and process is a basin wide collaboration of different level agencies and stewardship groups for protecting Lake Michigan. The LaMP is undergoing a process of making its information and recommendations more accessible and timely.The LaMP includes two to four page fact sheets for its 33 8-digit HUC watersheds. While well received, the information needs to be updated more often and provided on and at the 12-digit HUC level. As part of the effort of making LaMP information resources more accessible, the fact sheets have been added to USEPA's Watershed Central wiki website. Watershed Central is a wiki site designed to provide state, local, and voluntary watershed management entities with tools and information that will aide in successful watershed management and provide for sharing of information on watershed tools and experience. The information on the individual watersheds can be viewed by the public at

http://wiki.epa.gov/watershed2/index.php/Lake_Michigan. Representatives of local watershed groups and organizations operating within watersheds can provide additional information the watershed or create new wiki pages for smaller watersheds through a moderated process. This presentation will describe the sites and the process for updating and creating pages. *Keywords: Watersheds, Web-based tools, Lake Michigan, Policy making.*

BECK, S.J., Environmental Protection Agency, 77 W. Jackson Blvd., Chicago, IL, 60604. **Two Decades of Coordinated Monitoring and Reporting.**

Two Decades of Coordinated Monitoring and Reporting: The 1994,95 field year for the Lake Michigan Mass Balance project was a collaborative effort of federal agencies, over a dozen universities and the four Lake Michigan states. The base line data and subsequently developed models provided a tributary, sediment, and air deposition picture. In 2002,the Lake Michigan Lakewide Management Plan (LaMP) proposed the addition of nutrients to the LaMP's Critical Pollutants List. A partial re-sampling in 2005, and the 2007 Lake Michigan Pilot of the National Monitoring Design identified gaps in near shore and embayments. In 2008 planning began to develop a near shore base line from data to be compiled from the 2010 field year of Coordinated Science and Monitoring and the National Coastal Conditions sampling. Findings will be reported at the September 2011 State of Lake Michigan Conference and in the next LaMP. *Keywords: Coastal processes, Monitoring, Lake Michigan.*

BELETSKY, D.[1], BELETSKY, R.[1], SCHWAB, D.J.[2], ANDERSON, E.J.[1], and LANG, G.[2], [1]CILER, University of Michigan, Ann Arbor, MI; [2]Great Lakes Environmental Research Laboratory, Ann Arbor, MI. **Interannual variability of circulation in Saginaw Bay.**

A 3-dimensional circulation model of Lake Huron is used to calculate circulation and thermal structure in Saginaw Bay in 1993 and 2008 on a 2 km grid. The model is based on the Princeton Ocean Model of Blumberg and Mellor (1987). Model results show significant difference in circulation patterns and water exchange between the inner bay and the outer bay. The presence of an anticyclonic gyre near the entrance of Saginaw Bay in summer impacts water exchange between the lake and the outer bay as well. The size of this gyre varied between years, indicating potential importance of this phenomenon for interannual variability of chemical and biological processes in Saginaw Bay. Nested grid model was developed for the inner bay on a 200 m grid. Model results are tested with current observations. *Keywords: Model studies, Hydrodynamics, Lake Huron.*

BELKOVA, N.L., VORONOVA, S.O., and TERKINA, I.A., Ulan-Batorskaya str., 3, Irkutsk, 664033, RUSSIA. **Viable but unculturable bacteria from Lake Baikal: new results on cultivation.**

Lake Baikal is one of the deepest and oldest water reservoirs in the world. The peculiarities of baikalian water affect the diversity of microbial community. Low fraction of cultivable heterotrophic bacteria was determined in comparative investigation of deep water bacterial communities with cultivation-depended and molecular approaches. The main aim of the research was to use a filtration-acclimation method for viable, but uncultivable bacteria (VBNC) cultivation and their phylogenetic identification. The water samples were collected in the south basin of Lake Baikal from the surface layer and depth of 600 m. Filtrate was used in acclimatization experiment. Totally 32 colonies of previously uncultivable bacteria were grown and identified by 16S rDNA sequencing with high homology to genera Acinetobacter, Arsenicicoccus, Bacillus, Bacteroides, Micrococcus, Pseudomonas, and Staphylococcus. Directly from lake water bacteria of genera Caulobacter, Brevundimonas, Flavobacterium, Methylobacterium, Microbacterium, Paenibacillus, Rhodococcus, and Rhodopseudomonas were cultivated. In laboratory experiments we found that baikalian microbes passed into VBNC stage after 1 to 3 months of incubation in extreme conditions (low content of nutrients and low temperature of cultivation). This work was supported by RFBR № 09-04-00977a.
Keywords: Biodiversity, Lake Baikal, Microbiological studies.

BENNINGTON, V.[1], MCKINLEY, G.A.[1], URBAN, N.R.[2], and MCDONALD, C.P.[2], [1]University of Wisconsin-Madison, Atmospheric and Oceanic Sciences, Madison, WI, 53706; [2]Michigan Technological University, Civil and Environmental Engineering, Houghton, MI, 49931. **Spatial heterogeneity in Lake Superior carbon biogeochemistry.**

Globally, lakes, rivers, and reservoirs play an important role in the carbon cycle (Cole et al., 2007; Tranvik et al., 2009) but are ignored in regional scale carbon budgets, due to a lack of understanding of individual systems. Previous carbon budgets for Lake Superior have remained unbalanced (Cotner et al, 2004; Urban et al, 2005) but suggest a regionally significant flux of CO_2 to the atmosphere. Observational studies have been limited by the location and timing of discrete observations, which likely accounts for part of the imbalance. We develop a group of three dimensional hydrodynamic-ecosystem models of Lake Superior to determine whether spatial and temporal heterogeneity in lake physics and production can account for discrepancies in the carbon budget. The models sufficiently capture observations of circulation, chlorophyll, net primary production, pCO_2, and respiration. We show the seasonal cycle of lake surface pCO_2 and resulting air-lake CO_2 exchange. Lake dynamics control the shape of the seasonal cycle and interannual variability. Model results suggest that spatial heterogeneity in respiration may account for the imbalance in the carbon budget. Coupled models such as these can be utilized to select observation stations for lake intensive programs and long-term studies.
Keywords: Carbon cycle, Model studies, Lake Superior.

BENNION, D.H.[1], MANNY, B.A.[1], ROSEMAN, E.F.[1], KENNEDY, G.A.[1], BOASE, J.C.[2], and CRAIG, J.M.[1], [1]USGS - Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105; [2]U.S. Fish and Wildlife Service, Alpena Fishery Resources Office, 145 Water Street, Alpena, MI, 49707. **GIS Based Spatial Modeling for Remediation of Fish Spawning Habitat in the Connecting Channels of the Huron-Erie Corridor.**

Quantity and quality of available habitats determines fish and wildlife population production capacity. The US Environmental Protection Agency has designated the St. Clair River and Detroit River Areas of Concern (AOC) and as noted in 2004, project design for Michigan AOCs, including maps, was largely nonexistent. This project addresses AOC delisting goals for beneficial use impairments no. 3 (degradation of fish and wildlife populations) and no. 14 (loss of fish and wildlife habitat) by mapping major physical components of select fish spawning habitat, identifying missing components, and examining connectivity to surrounding habitats. Information from recent spawning habitat construction projects and spawning and larval fish studies is combined with spatial overlays of depth, water velocity and substrate type to identify and rank potential sites for future fish spawning habitat construction projects that will be sustained into the future by natural riverine forces. Other factors considered are proximity to maintained shipping channels, locations of potential pollution sources and potential connectivity to nursery habitats. *Keywords: St. Clair River, Fish spawning, Detroit River, GIS, Habitats, Mapping.*

BENSON, B.J.[1], MAGNUSON, J.J.[1], and JENSEN, O.P.[2], [1]Center for Limnology, University of Wisconsin-Madison, Madison, WI, 53706; [2]Rutgers University, Institute of Marine and Coastal Sciences, New Brunswick, NJ, 08901. **Extreme events, trends and variability in Northern Hemisphere lake ice phenology (1855 - 2005).**

Often extreme events, more than changes in mean conditions, have the greatest impact on the environment and human well-being. We examine changes in the occurrence of extremes in the timing of the annual formation and disappearance of lake ice in the Northern Hemisphere. Both changes in the mean condition and in variability (standard deviation) around the mean condition can alter the probability of extreme events. We used long-term ice phenology data covering two periods 1855-2004 and 1905-2004 for a total of 75 lakes, to evaluate the roles of changes in mean condition and variability. Ranges of rates of change (days per decade) among time periods were 0.2-1.6 later (freeze), 0.5-1.9 earlier (breakup), and 0.6-4.3 shorter (duration). Usually standard deviation did not change or it decreased in the 150-year and 100-year periods. The significant increases in the frequency of extreme lake ice events associated with warmer conditions and decreases in the frequency of extreme events associated with cooler conditions appeared to be primarily the result of changes in the mean ice dates rather than changes in variability over the recent 100 and 150 years. *Keywords: Ice, Lakes, Climate change, Long-term, Variability.*

BETZHOLD, L.D. and MATAOSKY, R.L., 2234 S. Hobson Ave., Charleston, SC, 29412. **Elevation Advances for Lake Superior and the Great Lakes: New Bathymetric Lidar and an Inventory of Coastal Elevation.**

Coastal elevation data is critical for designing restoration efforts, remediating stamp sands, evaluating essential fish habitat, enhancing navigation, and developing scenarios for lake level drop. In Lake Superior, very little bathymetric lidar has been collected, and this has been a major data gap. With funding from the Great Lakes Restoration Initiative, the Coastal Services Center contracted the collection of 900 linear km of bathymetric lidar along the coast of Lake Superior. The area of collection was determined using priorities from many federal, state, local, and regional groups. Not only has this data set filled a critical data gap, it will be put to use immediately by stakeholders involved in the prioritization process. In addition, the Topographic and Bathymetric Data Inventory was completed in 2010 for the Great Lakes region. The inventory is a national-scale online viewer that serves as an index to the best-available elevation data sets by region. It is designed to increase awareness of existing elevation data sets, identify gaps in coverage, and encourage collaboration for collection of new data sets. These two advances in elevation data coverage and availability will greatly enhance data access and will serve to meet many elevation needs across the region. *Keywords: Data storage and retrieval, Benthos, Lake Superior.*

BHAGAT, Y. and RUETZ III, C.R., Annis Water Resources Institute, Grand Valley State University, 740 West Shoreline Drive, Muskegon, MI, 49441, United States.
Determinants of fish community assemblages in drowned river mouth systems of Lake Michigan.

Drowned river mouth (DRM) lakes lie at the confluences of major river tributaries and large lake systems and as such, present unique ecosystems to investigate patterns of fish community assemblages. We examined the determinants of fish assemblages at 20 sites in DRM lakes of Lake Michigan. Using overnight fyke nets, we sampled the littoral fish community at our study sites between 2009 and 2010. Cluster analysis (Sorensen distance) performed on fish species relative abundances partitioned the sites into four groups. Indicator species analysis was used to identify the species that contributed most to the distinctiveness of each cluster. All four clusters, however, were represented mostly by centrarchid and cyprinid species. Stepwise discriminant function analysis revealed that the parameters that best separated the clusters were conductivity, temperature and organic sediment characteristics. In addition, clusters of sites were also separated by latitude and year sampled, suggesting that fish assemblages in these systems may vary annually and spatially. Results from this study will be compared to species assemblage patterns seen in similar systems that are also influenced by lake and river dynamics. *Keywords: Fish, Rivermouths, Lake Michigan, Littoral zone.*

BIBERHOFER, J.[1], SMITH, C.J.[2], and ANDRUCHOW, K.L.[1], [1]Environment Canada, WSTD, AEMRD, 867 Lakeshore Road, Burlington, ON, L7R 4A6, Canada; [2]Environment Canada, WSTD, Engineering, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Underwater Video Documentation of Selected Offshore Reefs and Shoals in Lake Huron.**

The recent condition of substrate on offshore reefs and shoals in Lake Huron has been documented at multiple sites with an underwater video system. The instrumentation, which includes cameras and lighting, a CTD and current meter, was deployed on semi-autonomous mooring that afforded stable platform for video and data recording. At each site the type and condition of substrate was documented as well as the distribution and relative density of dreissenid mussels and benthic algae. Several sites specifically targeted the areas previously described by Edsall et al (1992). Prior to the surveys, a 3D bathymetry model was developed for Lake Huron and Georgian Bay as a decision support tool for site selection and has also proven useful for other investigations. *Keywords: Lake Huron, Habitats, Fisheries.*

BIDWELL, D.[1], SCAVIA, D.[2], and DIETZ, T.[3], [1]Great Lakes Integrated Sciences and Assessments Center, 625 E. Liberty St., Suite 300, Ann Arbor, MI, 48104; [2]Graham Institute, University of Michigan, Ann Arbor; [3]Michigan State University, East Lansing. **GLISA: The Great Lakes Integrated Sciences and Assessments Center.**

The Great Lakes Integrated Sciences and Assessments Center (GLISA)--a collaboration of the University of Michigan and Michigan State University--is one of the newest NOAA-funded regional institutions focused on adaptation to climate change. GLISA facilitates the exchange of information between researchers and decision-makers in the Great Lakes region. It does this through three initial program areas: 1) tracking and building networks among researchers and decision makers, 2) identifying and evaluating climate models scaled to the regional or sub-regional level, and 3) supporting relevant research. GLISA's initial areas of focus are agriculture, water management, and natural resource-based recreation and tourism. This presentation will provide an overview of GLISA activities and summarize findings from an analysis of prior assessments of climate-related concerns and needs in the region. *Keywords: Climate change, Decision making.*

BINDING, C.E., BUKATA, R.P., and GREENBERG, T.A., Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **An analysis of MODIS-derived algal and mineral turbidity in the optically complex waters of Lake Erie.**

This paper presents observations of MODIS-derived algal and mineral particulates for Lake Erie, using inverse modelling of water-leaving radiance in the red and near infra-red to jointly extract concentrations of chlorophyll and mineral sediments. Modeling procedures are summarised, along with definitions of optical properties measured in Lake Erie. Image processing procedures, now operating on a near-real-time

basis, are described. Imagery for the years 2003-2010 are analysed to study spatial and temporal variability in mineral turbidity and algal bloom dynamics on the lake in order to highlight regions of enhanced algal productivity and low water clarity.
Keywords: Remote sensing, Lake Erie, Water quality.

BINDING, C.E.[1], GREENBERG, T.A.[1], BUKATA, R.P.[1], LETOURNEAU, G.[2], and WATSON, S.B.[1], [1]Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [2]Environment Canada, 105 McGill, Montreal, QB, H2Y2E7. **Satellite Remote Sensing of Potentially Harmful Algal Blooms in Lake of the Woods.**

With its remote location and its hydrologically complex waters, Lake of the Woods is a difficult waterbody to adequately monitor using in situ sampling alone. Results presented will demonstrate the potential of satellite remote sensing for monitoring algal blooms on the lake. Optical properties of Lake of the Woods waters were measured and a full assessment of chlorophyll products from the MERIS sensor was carried out during an intense surface algal bloom in September 2009. Images are shown to adequately identify the bloom and are used to track the evolution of the bloom across the lake. Evidence is presented of the effects of variable depth distributions of cyanobacteria on the surface signal seen by the sensor; imagery suggests that day to day variations in wind-induced mixing have a profound impact on surface algal biomass as detected by remote sensing. *Keywords: Remote sensing, Water quality, Algae.*

BISTA, D., KUHANECK, R.M., MISHRA, S., PHILIPS, M., ARMENIO, P., CHAFFIN, J., HECKATHORN, S.A., and BRIDGEMAN, T.B., University of Toledo, Dept. of Environmental Sciences and Lake Erie Center, Toledo, OH, 43606. **Use of natural algal assemblages as seed-stock for biofuel production.**

We are investigating the potential of using natural algal assemblages as seed-stock for biofuel production, as a means to increase growth and lipid production, while decreasing cost and technology. Algae were collected from Lake Erie with plankton nets, partially fractionated after overnight settling to enrich for diatoms, and grown in a 3800-L circulating bioreactor or in 200-L non-circulating batch cultures. In replicate trials and both reactor types, lake assemblages grown in high N quickly became dominated by a high-lipid green-alga (*Chlorella* sp.), and growth was affected by N and contaminating invertebrate grazers; lipid content was variable (7-28% of dry mass) and inversely related to growth. In other trials, diatom-enriched fractions were also outcompeted by green algae unless grown at low N & P, which reduced growth. Light color during growth (e.g., orange for diatoms) and pre-treatment of seed-stock with taxa-specific inhibitors (e.g., cellulose for green algae) were successful in promoting growth of desired vs. undesired taxa; N2-bubbling pre-treatment is being tested as a means to inhibit herbivores. These results indicate that natural mixed-species communities may be used successfully as biofuel seed-stock, and a toolkit of simple methods can be used to promote growth of desired algal taxa. *Keywords: Phytoplankton, Biofuel, Algae.*

BLANKEN, P.D.[1], SPENCE, C.[2], and HEDSTROM, N.[2], [1]University of Colorado, Department of Geography, Boulder, CO, 80309-0260; [2]Environment Canada, 11 Innovation Boulevard, Saskatoon, SK, S7N 3H5. **Direct Measurements of the Surface Energy Balance on Lake Superior.**

The surface energy balance was measured using the eddy covariance method from a remote site on Lake Superior nearly continuously at 0.5-hr intervals from June 2008 through November 2010. Pronounced seasonal patterns in the surface energy balance were observed, with a five-month delay between maximum summer net radiation and the maximum winter latent and sensible heat fluxes. Late season (winter) evaporation and sensible heat losses from the lake occurred in 2-3 day-long events, driven by the release of stored heat from the lake. The majority of the evaporative heat loss (70-88%) and sensible heat loss (97-99%) occurred between October-November and March, with 464 mm (2008-2009) and 645 mm (2009-2010) of evaporative water loss occurring over the water year starting October 1. Evaporation was proportional to the horizontal wind speed, and inversely proportional to the ambient vapor pressure, and was well described by the ratio of wind speed to vapor pressure. The connections between the surface energy balance and lake ice cover/duration are discussed. *Keywords: Lake Superior, Atmosphere-lake interaction, Climatology.*

BLANN, K.L., 40234 U.S. Hwy 10, Cushing, MN, 56443, US. **Developing Biological and Ecological Criteria to Protect Environmental Flows in Minnesota.**

Hydrology is increasingly recognized as a primary determinant of aquatic, riparian and shoreland ecological structure and function. Surface and groundwater use, landscape modification, and climate change can all modify basin hydrology and streamflow regimes, but the quantitative relationship between these changes and ecological outcomes is often insufficiently defined for design of effective conservation policy. This presentation will address recent progress on an initiative led by The Nature Conservancy to advance understanding of ecological flow needs in Minnesota and establish ecological criteria for assessing and preventing flow alteration in aquatic systems. The initial stages of the project focus on a) assessing available data, criteria, tools and approaches to development of ecological flow criteria (both science and policy), b) developing consensus on technical approaches to characterizing flow metrics and ecological response, c) and assessing ecological flow response relationships for Minnesota's Great Lakes Basin streams as a pilot to identify and develop flow metrics and criteria needed to protect aquatic systems statewide. This effort also seeks to expand the environmental flow protection framework to the assessment and protection of natural hydrologic variation in lake and wetland basins. *Keywords: Conservation, Bioindicators, Policy making.*

BLASS, C.R., GEHRING, T.M., MURRY, B.A., and UZARSKI, D.G., Institute of Great Lakes Research and Department of Biology, Central Michigan University, Mount Pleasant, MI, 48859. **Mute Swan Impacts on Great Lakes Coastal Wetland Health Using a Macroinvertebrate-Based Index of Biotic Integrity.**

Great Lakes coastal wetlands provide critical habitat and refugia for larval and adult aquatic macroinvertebrates, which supports many higher-level taxa. Coastal wetlands are degraded by anthropogenic disturbances, including the introduction of invasive mute swans. Indices of Biotic Integrity (IBI) have been developed and validated using macroinvertebrate community composition in inundated *Typha* or *Schoenoplectus* plant zones to provide an assessment of the quality of coastal wetlands. This study will determine how mute swans impact macroinvertebrate community composition. Coastal wetlands along Michigan's shoreline in Lakes Huron and Michigan were sampled using dip net triplicates in each plant zone and surveyed for mute swans. Macroinvertebrates were identified to the lowest operational taxonomic unit (LOTU) in the lab. Sites were categorized by presence or absence of mute swans with relative abundance calculated for each LOTU caught and Simpson's and Shannon Diversity and species evenness for each plant zone. IBI metrics were scored within each plant zone and related to swan presence and absence. Changes in coastal wetland health due to mute swans may suggest that mute swans are potential ecosystem engineers. *Keywords: Indicators, Invasive species, Macroinvertebrates.*

BOASE, J.C.[1], DONALD, K.A.L.[2], KENNEDY, G.A.[3], MANNY, B.A.[3], DIANA, J.S.[2], and THOMAS, M.V.[4], [1]Alpena Fish and Wildlife Conservation Office, Waterford Substation, 7806 Gale Rd., Waterford, MI, 48327; [2]University of Michigan, SNRE, Dana Building, Ann Arbor, MI, 48109; [3]USGS Grea Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105; [4]Michigan Department of Natural Resources, Mount Clemens Fisheries Research Station, 33135 South River Rd., Mt. Clemens, MI, 48045. **Habitats occupied by Juvenile Lake Sturgeon (Acipenser fulvescens) in the North Channel of the St. Clair River.**

Lake Sturgeon occupy the St. Clair R., part of the channel connecting lakes Huron and Erie in the Great Lakes. In the N. Channel of St. Clair R., juvenile Lake Sturgeon (374-793 mm) were studied to determine movement patterns and habitat use. Seventeen juveniles were implanted with ultrasonic transmitters and tracked in 2004, 05, and 06. Telemetry data, GIS software, and substrate samples were used to determine the extent and composition of habitats occupied. Lake Sturgeon showed a large degree of site fidelity; home range varied from 0.8-10.8 square km. Habitat selection was strongly related to water depth with 95% of observation >9m, and most commonly (44%) between 12-18 m. Implanted juvenile fish had a high degree of home range overlap and was significantly higher in areas that contained gravel bottom substrate without zebra mussels. Home range was also smaller in areas that contained gravel substrate than in areas covered with appreciable zebra mussels or zebra mussel shells. A significant negative correlation was found between the amount of zebra mussel coverage and water depth. Substrates at greater depths had lower zebra mussel coverage. Our findings are

consistent with the hypothesis that juvenile Lake Sturgeon occupy deeper areas of the N. Channel because those areas lack zebra mussels and contain gravel substrates.
Keywords: St. Clair River, Fish spawning, Lake Sturgeon, Habitat.

BOCANIOV, S.A.[1], SCHWALB, A.N.[1], SPILLMAN, C.M.[2], HIPSEY, M.R.[3], LEON, L.F.[4], MOLOT, L.A.[5], and SMITH, R.E.H.[1], [1]University of Waterloo, Waterloo, ON, Canada; [2]Australian Bureau of Meteorology, Melbourne, Australia; [3]University of Western Australia, Crawley, Australia; [4]National Water Research Institute, Burlington, ON, Canada; [5]York University, Toronto, ON, Canada. **Can we model the impact of invasive dreissenid mussels on large lake ecosystems? A three-dimensional modeling study of Lake Erie and Lake Simcoe.**

The invasion of dreissenid mussels has drastically altered aquatic ecosystems in North America including large lakes. According to the nearshore-shunt hypothesis mussels are expected to redirect nutrients and energy to the benthos, and to have their greatest impact in shallow, well mixed nearshore areas. However, these processes are difficult to assess with measurements in the field and result are often confounded by hydrodynamic effects and spatial variation, whereas modeling that includes 3D spatial complexity and hydrodynamic processes can give important insight. We used a 3D hydrodynamic and ecological model (ELCOM-CAEDYM) that includes routines to describe nutrient cycling, phytoplankton dynamics, mussel energetics and the physical-biological processes controlling food particle availability proximate to the mussels. Surprisingly, mussels not only decreased phytoplankton substantially in the nearshore, but also in the offshore. Our model also predicted strong spatial variability reflecting differences in mussel density. The strongest effects were seen in the east basin, followed by the west basin, whereas mussels had relatively little impact on phytoplankton in the central basin. Results for the smaller, shallower, but heavily mussel-colonized Lake Simcoe revealed both similarities and differences to patterns seen in Erie.
Keywords: Dreissena, Model studies, Lake Erie.

BOOTH, N.L., BLODGETT, D.L., KUNICKI, T.C., KUO, I., and KRANENDONK, L.A., 8505 Research Way, Middleton, WI, 53562. **USGS Center for Integrated Data Analytics - Great Lakes Restoration Initiative Data Network.**

Environmental baselines, mechanisms to prioritize restoration investments and tools to evalute environmental changes are critical for planning and understanding the success of the Great Lakes Restoration Initiative (GLRI). Complexity of the ecosystem and the number of partner organizations involved in GLRI requires a robust and comprehensive data integration framework. The USGS Center for Integrated Data Analytics (CIDA) is working with GLRI partners to develop and implement a GLRI Data Network that will provide access to information collected throughout GLRI. By integrating monitoring data and computer models that encompass the watershed, airshed, near-shore and deepwater environments of the Great Lakes, the GLRI Data Network will enable policy makers to plan and evaluate restoration activities based on science that holistically represents the Great Lakes system. Beyond supporting USGS GLRI research, CIDA is working with USGS scientists, NOAA's Great Lakes Environmental Research Lab and the Great Lakes Observation System to design and implement the inland-watershed and near-shore components of a Great Lakes observing system. While the objectives are ambitious, much work has been done or is underway contributing to the network, cyber-infrastructure design, and implementation. *Keywords: Data acquisition, Monitoring, Watersheds.*

BOSCH, N.S.[1] and ALLAN, J.D.[2], [1]200 Seminary Dr., Winona Lake, IN, 46590; [2]440 Church St., Ann Arbor, MI, 48109. **Using the Soil and Water Assessment Tool (SWAT) to Evaluate the Impact of Nutrient Source Reduction and Agricultural BMP Implementation on Riverine Loads to Lake Erie.**

We used the Soil and Water Assessment Tool (SWAT) applied to six watersheds draining into Lake Erie to simulate various nutrient source reduction activities and implementation of agricultural best management practices (BMPs). The SWAT watershed models were calibrated and validated for stream discharge and water quality parameters using data from 1998-2005 by using time series plots and statistical measures to verify model predictions. Simulated hydrology and water quality parameters closely resembled observed data overall. For several source reduction and BMP scenarios we predict changes in streamflow and sediment and nutrient loads in river export. SWAT scenarios showed that moderate implementation of agricultural BMPs had a limited effect on sediment and nutrient export from all watersheds. Certain BMPs were shown to be more effective at reducing riverine sediment and nutrient fluxes than others. More detailed scenarios with just the Maumee River watershed showed limited effectiveness of source reduction strategies as well. Changing locations of BMP implementation and more extensive combinations of BMP implementation approaches were much more effective in reducing nutrient and sediment loads from the Maumee watershed into Lake Erie. *Keywords: Nutrients, Watersheds, Lake Erie.*

BOSTROM, J.R.[1], OSTER, R.J.[1], LEE, J.S.[2], LITTLE, B.J.[2], and HICKS, R.E.[1], [1]UMD Biology, 1035 Kirby Dr, Duluth, MN, 55812; [2]Naval Research Laboratory, Code 7332, Stennis Space Center, MS, 39529. **Microbiological and Chemical Aspects of Corrosion of Steel in the Duluth-Superior Harbor.**

Sheet steel structures in the Duluth-Superior harbor show an unusual corrosion pattern characterized by severe pitting underneath rusty blisters called tubercles. A microcosm experiment was designed to evaluate the effects of microbes and water quality on the corrosion process. Duplicate steel coupons were evaluated in five treatments: unaltered harbor water, autoclaved harbor water, autoclaved harbor water with iron-oxidizing bacteria (FeOB), harbor water supplemented with sulfate and Lake Superior water. T-RFLP analyses showed that bacterial communities on coupons were different from one another in microcosm treatments with different water types (e.g. Lake Superior or Duluth-Superior harbor water). The abundance of the dissimilatory sulfite reductase

gene, an indicator of sulfate-reducing bacteria (SRB), was greater on coupons in harbor water (with or without added sulfate) than on coupons incubated in Lake Superior water after five months. By the end of the experiment, there were more FeOB on coupons immersed in harbor water than other treatments. SRB abundance and to a lesser degree FeOB abundance were correlated with overall differences between bacterial communities and instantaneous corrosion rates. These data indicate that microbes as well as water quality may influence the corrosion of steel structures in this harbor.
Keywords: Microbiologically Influenced Corrosion, St. Louis River AOC, Biofilm.

BOUDREAU, R.P., Parks Canada Agency, Box 998, Nipigon, ON, P0T 2J0. **Lake Superior National Marine Conservation Area.**

The Lake Superior National Marine Conservation Area (NMCA) at 10,850 sq km's is the largest freshwater protected area in the world and is part of a nation-wide family of protected natural heritage places managed by Parks Canada. Parks Canada plans to have 29 Natural Marine Regions across Canada. The intention is to eventually have each region represented by a marine conservation area. The objective of the program is to protect and conserve, for all time, marine areas that are representative of Canada's oceans and Great Lakes for the benefit, education and enjoyment of the world. We also intend to increase public understanding, enjoyment, and appreciation of Canada's marine heritage. A NMCA is managed for ecological sustainable use. This will require benchmarking biotic and abiotic components as we move forward in establishing Lake Superior NMCA. Parks Canada intends to develop partnerships with universities and colleges regarding research within the NMCA. Parks Canada's presentation will be focused on the Lake Superior NMCA - the history of it, why it was chosen, where we are now, and the steps in moving forward. *Keywords: Management, Lake Superior, Planning.*

BOURDEAU, P.E.[1], PANGLE, K.L.[2], and PEACOR, S.D.[1], [1]Department of Fisheries and Wildlife, East Lansing, MI, 48824; [2]Department of Evolution, Ecology and Organismal Biology, Columbus, OH, 43212. **Non-Consumptive Effects on Lesser-Preferred Prey: Does *Bythotrephes* Affect the Vertical Distribution and Migration of Native Copepods in the Great Lakes?**

Predators can have strong negative effects on prey through non-consumptive pathways by inducing prey behavioral modifications. The behavioral response magnitude of native prey to invasive predators can vary greatly from no to strong changes. In Lake Michigan the invasive planktivore *Bythotrephes* induces strong vertical migration in a preferred prey, *Daphnia mendotae*. Increased migration presumably diminishes predation from *Bythotrephes*, but also reduces birth rate due to exposure to cooler temperatures. This latter effect represents strong negative non-consumptive effects on *Daphnia*. We examined whether other zooplankton that are less preferred by *Bythotrephes* respond similarly. Field surveys indicated that higher *Bythotrephes* abundance was correlated with some groups of copepods occupying lower vertical positions and vertically migrating. Experiments elucidated these patterns, showing that copepods respond to *Bythotrephes* water-borne cues by migrating to lower positions in experimental columns. We discuss how varied behavioral responses by different zooplankton to *Bythotrephes* may alter their interactions with each other, their resources, and other predators, suggesting the complex effects *Bythotrephes* can have on invaded pelagic communities in the Great Lakes. *Keywords: Biological invasions, Non-consumptive effects, Bythotrephes cederstroemii, Migrations.*

BOURGEAU-CHAVEZ, L.L.[1], POWELL, R.B.[1], JENKINS, L.K.[1], BROOKS, C.N.[1], ERICKSON, T.A.[1], MAZUR, M.C.[2], KOWALSKI, K.P.[2], HUBERTY, B.J.[3], and RIORDAN, K.[1], [1]3600 Green Court, Suite 100, Michigan Tech Research Institute, Ann Arbor, MI, 48105; [2]1451 Green Road, USGS Great Lakes Science Center, Ann Arbor, MI, 48105; [3]1 Federal Drive, US Fish and Widlife Service - Ecological Services, Fort Snelling, MN, 55111-4056. **Mapping and Monitoring of Invasive Phragmites in the Coastal Great Lakes using Radar Imagery.**

Great Lakes coastal wetlands are increasingly at risk due to anthropogenic influences such as the introduction of non-native species and require monitoring for effective management. Of particular concern is the non-native common reed, Phragmites australis, which has significant impacts on ecosystem services. Currently there is no comprehensive of the extent of Phragmites infestation in the Great Lakes region. In a project funded through USGS Great Lakes Science Center and US Fish & Wildlife Service as part of the Great Lakes Restoration Initiative, we have applied our methods using L-band SAR data to mapping Phragmites across the U.S. side of the entire Great Lakes basin from the shoreline to 10 km inland. The method uses multi-temporal synthetic aperture radar (SAR) data from ALOS PALSAR and ground reference data to map known and potential Phragmites locations with a minimum area of 0.5 acres. Multiple dates of PALSAR dual polarization data are used to capture seasonal variations and exploit band ratio differences between Phragmites and other wetland species such as Typha (cattails). Ground reference data has been collected at over 600 wetland locations across the entire. The project will result in a comprehensive map of potential Phragmites locations for the U.S. side of the coastal Great Lakes. *Keywords: Invasive species, Remote sensing, Wetlands.*

BOWERMAN, W.W.[1], BEST, D.A.[2], SIKARSKIE, J.G.[3], and GRUBB, T.G.[4], [1]Department of Environmental Science & Technology, University of Maryland, College Park, MD, 20742; [2]U.S. Fish & Wildlife Service, East Lansing Field Office, East Lansing, MI, 48823; [3]College of Veterinary Medicine, Michigan State University, East Lansing, MI, 48824; [4]U.S. Forest Service, Rocky Mountain Station, Flagstaff, AZ, 86001. **How 50 Years of Bald Eagle Population Monitoring Helps Us Understand the Great Lakes.**

Bald eagle populations in North America were negatively impacted from DDT and other factors after World War II. By the late 1960s, few eagles were nesting along the shorelines and islands of the Great Lakes. Statewide surveys of nesting eagles began in 1961 by the National Audubon Society. Fifty annual surveys have been conducted in Michigan, documenting over 10,500 known reproductive outcomes. Eagles are tertiary predators at the top of the Great Lakes food web. The effects of many different stressors are quantifiable. This includes known NOAECs for many organochlorine compounds. Monitoring programs utilize blood, feathers, and unhatched eggs to determine spatial and temporal trends of environmental contaminants. Recently, nesting chronology has been developed as an indicator of potential effects of global climate change. Eagles nesting along the shorelines and tributaries of the Great Lakes are nesting nearly 1 day earlier over the past 20 years. The use of eagles as ecosystem health indicators has been proposed for use by both the IJC and SOLEC. The recovery of the eagles in Michigan is one of the most tangible examples of the positive outcome of regulation of persistent organic compounds, and the recovery of the Great Lakes. Their use as potential monitors of climate change show the utility of longterm studies. *Keywords: Population monitoring, Ecosystem health, Bald eagle, Climate change, Avian ecology.*

BOWMAN, D.W.[1], CLARK, G.R.[2], SHARROW, J.D.[3], BROSSART, S.J.[4], SERCK, J.L.[5], and SCOTT, C.E.[6], [1]U.S. Army Corps of Engineers, P.O. Box 1027, Detroit, MI, 48231; [2]University of Wisconsin Sea Grant Institute, 153 Hawkes Hall, Superior, WI, 54880; [3]Duluth Seaway Port Authority, 1200 Port Terminal Drive, Duluth, MN, 55802; [4]U.S. Army Corps of Engineers, 600 Lake Street, Duluth, MN, 55802; [5]1316 N. 14th St., Superior, WI, 54480; [6]AMI Consulting Engineers, 91 Main St., Superior, WI, 54880.
Accelerated Corrosion in the Duluth-Superior Harbor.

The U.S. Army Corps of Engineers was asked to investigate the corrosion of steel structures in the Duluth-Superior Harbor. During 2004 the Corps convened an expert panel to review existing data for the harbor and make recommendations about potential causes to investigate. The expert panel recommended evaluating several water quality parameters, stray electrical currents, and the potential for microbially influenced corrosion, as possible causes of accelerated corrosion. In 2006 the Corps developed an investigative team including expertise from the Universities of Minnesota and Wisconsin. The Corps and Ports conducted surveys of the structures in the harbor and conducted water quality monitoring. They also partnered to place steel coupons in the harbor to measure corrosion rates. The impacts of accelerated corrosion became even more apparent when Lake Superior water levels dropped in 2007, exposing infrastructure that had been destroyed by corrosion. In addition to the causes of corrosion, the team also undertook to identify methods to protect the existing steel in the harbor. The Corps recommended coatings that could be applied to the steel for protection and an initial set of coupons was placed at a depth of four feet (zone of most accelerated corrosion). A second set was placed in the ice scour zone to assess impacts. *Keywords: St. Louis River AOC, Corrosion, Control systems, Lake Superior.*

BOYER, G.L.[1], PAVLAC, M.M.[1], KONOPKO, E.[1], SULLIVAN, J.M.[1], and WATSON, S.B.[2], [1]Department of Chemistry,, SUNY-College of Environmental Science and Forestry,, Syracuse, NY, 13210; [2]Environment Canada,, National Water Research Institute,, Burlington,, ON, L7R 4A6. **Blue-Green Algae are not Green Algae - Calibration and Application of *In Situ* Sensors for Cyanobacteria.**

Lake Ontario and Lake Erie commonly experience large blooms of cyanobacteria. Some (not all) of these blooms can contain toxins that may propose a risk to human health. To aid in monitoring efforts, autonomous sensors for cyanobacteria that can detect potentially-toxic blooms in near time are needed. Simple fluorescence-based sensor for the pigments phycocyanin and phycoerythrin provide an easy presence-absence determination for cyanobacteria. However basic differences in the photophysiology and biochemistry of cyanobacteria make calibration of these sensors problematic. Multichannel fluorometers such as the BBE FluoroProbe offer increased differentiation between cyanobacteria and eukaryotic algae, however are limited to the class level. Genus-level differentiation is possible using a modified optical phytoplankton discriminator (OPD). As part of ongoing efforts through the Great Lakes Observing System and with Environment Canada, several different fluorometers, including simple sonde-mounted sensors, AlgaeWatch and CyanoWatch systems, a FluoroProbe, and the OPD were deployed on the CCGS Limnos in different cruises between 2005-2010. Results from these different cruises, as well as lab experiments and the trials and tribulations of calibration and quality control of the different systems will be presented.
Keywords: Lake Erie, Cyanobacteria, Lake Ontario, Algae.

BRANSON, D.R. and MCNAUGHT, A.S., Central Michigan University, Brooks Hall, Mt. Pleasant, MI, 48859. **Feeding Behavior of a Recent Great Lakes Invasive Mysid, *H. anomala*.**

Hemimysis anomala, a mysid from the Ponto-Caspian region, is a recent invader of the Great Lakes. In Europe, where *H. anomala* has been introduced, significant changes in zooplankton abundance and diversity have been identified; however, little is known about *H. anomala*'s feeding behavior. Laboratory trials were performed to determine the feeding rates and functional response of *H. anomala* on various sizes of *Daphnia* and *Artemia* nauplii. *H. anomala* were collected from Muskegon Lake by towing a 30-cm net through visible swarms during winter months. The specimens were maintained in 450 L Live Stream tanks and fed freeze-dried *Artemia*. Individual *H. anomala* were starved for 24 hours and isolated in 600 ml beakers. Prey were introduced at densities of 20, 40, 60, and 80 per liter and surviving prey were counted at 4 and 6 hours then preserved. Trials were performed in light and dark conditions. *H. anomala* typically exhibited a Type II feeding response. Our trials demonstrate high consumption rates, especially of smaller prey items and under dark conditions. High consumption of *Artemia* nauplii and small *Daphnia* indicates that *H. anomala* may have a large impact on native copepods. *Keywords: Zooplankton, Food chains, Invasive species.*

BRIGHT, E., ROSEMAN, E.F., and SCHAEFFER, J., USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105. **Diets of angler-caught predators in Lake Huron, 2009-2010.**

We analyzed diets of over 4500 predators caught by anglers in Lake Huron during 2009 and 2010 to determine how predators have responded to recent changes in the prey base, especially near absence of alewife and low biomass of of other fish prey. Anglers captured primarily Chinook salmon, lake trout, walleye, steelhead, and Atlantic salmon. During 2009, prey fish were scarce, and predators relied on non-traditional prey. Most fish consumed round goby, but there was surprising reliance on invertebrate prey. Small, recently stocked lake trout and Chinook salmon comprised a substantial proportion of diets, and were occasionally the most prominent prey after stocking events. During 2010, gizzard shad and rainbow smelt were more abundant and their dietary proportions increased, but predators continued to consume non-traditional prey. Predators in Lake Huron appear to be prey-limited, and large-bodied prey seem especially rare. Prey limitation may be most severe for walleye, Chinook salmon and lake trout because their diet breadth was narrow. Atlantic salmon and steelhead may be less affected because of their wider diet breadth. Our results may also explain recent declines in survival of stocked salmonids because predation on them seemed especially severe.
Keywords: Food chains, Fish diets, Predation.

BROOKS, C.N.[1], SAYERS, M.J.[1], KERFOOT, W.C.[2], SHUCHMAN, R.A.[1], GREEN, S.A.[3], SABOL, B.M.[4], JESSEE, N.L.[1], YOUSEF, F.[2], and ENDSLEY, K.A.[1], [1]3600 Green Court, Suite 100, Ann Arbor, MI, 48105; [2]1400 Townsend Drive, Department of Biological Sciences, Houghton, MI, 49931; [3]1400 Townsend Drive, Department of Chemistry, Houghton, MI, 48105; [4]3909 Halls Ferry Road, US Army Corps of Engineers, Vicksburg, MS, 39180. **Assessing Impacts from Historical Copper Mining Stamps Sands in the Keweenaw Peninsula through Analysis of LiDAR and Multispectral Imagery from the US Army Corps of Engineers CHARTS System.**

A Michigan Tech University - US Army Corps of Engineers (USACE) collaborative team has been analyzing 2008 USACE CHARTS LiDAR and multispectral CASI imagery collected over areas of stamp sands deposited during the historical copper mining period in Michigan's Keweenaw Peninsula. Our focus area has been the area near Gay, MI, where approximately 23 million metric tons of mining stamp sands were deposited between 1901 and 1932, which have been eroding into Lake Superior. We have enhanced a depth-invariant index algorithm to demonstrate how multispectral CASI imagery can be used to map underwater areas of remaining native sand vs. deposited stamp sands. We have also developed methods to analyze LiDAR waveforms to detect patterns of varying bottom types. To enhance mapping of the lake bottom, we have developed a sun-glint and surface wave removal algorithm. We have demonstrated a method of fusing CASI imagery with LiDAR data to improve classification of nearshore wetland and forested areas. Using the 2008 LiDAR data to calculate stamp sand height and volume along with historical aerial imagery, we estimate that approximately 8.6 million metric tons of stamp sands remain on-shore as of 2008 and 14 million metric tons have been deposited into the nearshore area that includes known fishery spawning grounds. *Keywords: Remote sensing, Mining, Lake Superior, Copper.*

BROUDER, M.J. and QUINLAN, H.R., U.S. Fish and Wildlife Service, Ashland Fish and Wildlife Conservation Office, 2800 Lake Shore Drive, East, Ashland, WI, 54806.
Use of low-cost side scan sonar to map nearshore coaster brook trout habitat at Isle Royale National Park, Lake Superior.

A remnant population of lake dwelling, shoreline spawning "coaster" brook trout exists within Tobin Harbor of Isle Royale National Park in Lake Superior. For over a decade, the status of this remnant population of coaster brook trout has been evaluated, however, more recently, efforts have shifted toward increasing our understanding of the use and availability of the shoreline habitats found within Tobin Harbor by "coasters." Side scan sonar technology has been used for decades as one approach to detecting and mapping benthic features of marine and deep freshwater systems. Traditional side scan sonar is expensive and typically involves towing an underwater sensor, limiting its use in relatively shallow water. We used an inexpensive (~$2000) Humminbird® 1100-series Side Imaging system to map and classify the nearshore (<20m) habitat (LWD, substrate, and depth) of Tobin Harbor. Future work will involve overlaying historic, current, and future coaster brook trout assessment data to our recently collected habitat data to better understand habitat preferences of this remnant population. *Keywords: Lake Superior, Trout, Habitats.*

BROUSSEAU, C.M., RANDALL, R.G., and DOOLITTLE, A.G., 867 Lakeshore Road, Great Lakes Laboratory for Fisheries and Aquatic Sciences, Burlington, ON, L9H 1S6.
Examining Invasive Fsh-Habitat Linkages at Different Spatial Scales.

Nearshore boat electrofishing data collected over a number of years from the lower Great Lakes will be used to explore linkages between non-native fish occurrence and habitat characteristics at three spatial scales. Fish occurrence will be measured using an Index of Biotic Integrity and other multi-metric methods. At the micro-scale, linkages between fish occurrence and shoreline and in-water attributes in close proximity to the survey locations will be investigated, including natural versus altered shorelines, substrate (particle size, natural and artificial) and macrophyte abundance. At the meso-scale, fish occurrence will be related to the vicinity of wetlands, harbours and exposed shorelines. At the regional scale, the effect of landscape characteristics (urbanization, agriculture and natural lands) on nearshore fish distribution will be investigated. This multi-spatial scale investigation will help identify the relative importance of proximate versus distal habitat factors on fish distribution in the Great Lakes. Comparisons will also be made with other studies in North America. *Keywords: Fish, Landscape characteristics, Spatial analysis, Fish habitat, Biological invasions.*

BRUXER, J.K.[1], MOIN, S.M.A.[2], and GUO, Y.[3], [1]Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6, Canada; [2]International Upper Great Lakes Study, International Joint Commission, 234 Laurier Avenue West, Ottawa, ON, K1P 6K6, Canada; [3]McMaster University, 1280 Main Street West, Hamilton, ON, L8S 4L8, Canada. **Uncertainty in Lake Erie Net Basin Supplies.**

The Lake Erie net basin supply (NBS) is defined as the net volume of water entering or exiting the lake from its own drainage basin over a specified period of time. NBS can be computed using either the component or residual method. In this research, an uncertainty analysis was performed on the Lake Erie residual NBS using both the First-Order Second Moment (FOSM) method and a Monte Carlo simulation approach. Uncertainties in each of the various inputs, including the Detroit River inflow, the Niagara River and Welland Canal outflows, and the change in storage, among other sources, were first defined through analysis of data, when available, or with alternative methods when necessary. The results obtained using the FOSM and Monte Carlo approaches were found to be nearly identical. Comparison of the results of this research to results from previous studies showed that the overall uncertainties in NBS are of a similar magnitude: however, the uncertainty in the change in storage was found to be greater than previously suggested as a result of meteorological impacts on measured Lake Erie water levels. *Keywords: Lake Erie, Uncertainty analysis, Hydrologic budget, Water balance.*

BUGLIOSI, E.F., U. S. Geolgicl Survey, 30 Brown Rd., Ithaca, NY, 14850. **U. S. Geological Survey Integrated Tributary Monitoring To Support Great Lakes Restoration Efforts.**

To support Great Lakes Restoration Initiative (GLRI) program goals, the U. S. Geological Survey is collecting inorganic and organic water-quality data from fifty-nine tributaries to the Great Lakes. These data will provide a baseline metric to assess restoration goal progress. Fifty-nine sites from the National Monitoring Network for Coastal Waters (NMN) in the Great Lakes basin are included. At all MNN sites passive integrative samplers are deployed to sample hydrophilic and lipophilic environmental contaminants. Thirty of the sites are equipped with automatic-sampling systems and multi-parameter sensors for measuring inorganic water-quality. The auto samplers will collect water-quality from storm events to supplement monthly base flow samples. Continuous sensor measurements will be used as surrogates to produce real-time, concentration estimates of additional chemical constituents Regression models will provide (estimates of real-time loading for the major Great Lakes tributaries. Fourteen sites will also be sampled for "chemicals of emerging concern" (CEC), including pharmaceuticals and personal care products. Fourteen sites will also employ sediment traps to measure PAHs, Total PCBs, and pharmaceuticals. Human and bovine virus samples will be collected to determine virus occurrence at eight of the fourteen CEC sites. *Keywords: Water quality, Toxic substances, Nutrients.*

BUNNELL, D.B., DAVIS, B.M., WARNER, D.M., CHRISCINSKE, M.A., KEELER, K.M., PUCHALA, E.A., and ROSEMAN, E.F., USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105. **Determining the impact of Bythotrephes on the Lake Huron zooplankton community.**

Between 2003 and 2007, several trophic level indicators in Lake Huron underwent declines, including chlorophyll, Diporeia, zooplankton, planktivorous fishes, and piscivores. Using field sampling and bioenergetics modeling, we evaluated whether consumption by fish (rainbow smelt, bloater) and invertebrate (Mysis, Bythotrephes) planktivores exceeded zooplankton production between May and October 2007. Bythotrephes was the dominant planktivore, estimated to have eaten 78% of all zooplankton consumed, and exceeded total zooplankton production between July and October. Mysis consumed 19% of all the zooplankton consumed, and exceeded zooplankton production in October. Consumption by fish was relatively unimportant- eating only 3% of all zooplankton consumed. Our results provide no support for the hypothesis that excessive fish consumption directly contributed to the decline of cladocerans and cyclopoid copepods. We also report on the seasonal dynamics of the epilimnetic zooplankton community in 2007- which presumably would have been regulated by Bythotrephes. Overall, this work highlights the importance of invertebrate planktivores in structuring zooplankton communities, especially for those foods webs that have both Bythotrephes and Mysis, given that they leave limited refuge for zooplankton prey. *Keywords: Bythotrephes cederstroemii, Predation, Zooplankton.*

BURLAKOVA, L.E.[1], LUCY, F.E.[2], KARATAYEV, A.Y.[1], MASTITSKY, S.E.[3], and ZANATTA, D.T.[4], [1]Great Lakes Center, Buffalo State College, Buffalo, NY, 14222; [2]Department of Environmental Science, Institute of Technology, Sligo, Ireland; [3]Department of Theoretical Bioinformatics, German Cancer Research Center, Heidelberg, Germany; [4]Biology Department, Central Michigan University, Mount Pleasant, MI, 48859. ***Dreissena* Impacts on Unionidae: General Trends in North America and Europe.**

The continued invasion of zebra mussels (*Dreissena polymorpha*) and quagga mussels (*Dreissena rostriformis bugensis*) in North America and Europe has threatened the survival of native unionid mussels. We used data from multiple waterbodies in Europe and North America at different stages of *Dreissena* invasion to test the relationships between the number and weight of attached zebra mussels per unionid host, densities of dreissenids in a waterbody, and time since invasion. We found a strong positive linear relationship between the number of zebra mussels per unionid host and *Dreissena* density in a waterbody. Nevertheless, both European and North American datasets indicated that a high percentage of unionids will be colonized even when zebra mussel density in a waterbody is low. We found an overall trend for increase of attached dreissenid weight with unionid host's size during the first 10 years after *Dreissena* invasion. However, our results suggest that this adverse impact reduces beyond 10 years after the recorded invasion. We discuss possible mechanisms for coexistence of

dreissenids and unionids, and make recommendations for future studies.
Keywords: Zebra mussels, Biological invasions, Unionids.

BURNISTON, D., MCCRAE, B., KLAWUNN, P.J., and DOVE, A., Environment Canada, Canada Centre for Inland waters, Burlington, ON, L7R 4A6, Canada. **Upstream / Downstream Water Monitoring.**

The St. Clair and Detroit Rivers, together with Lake St. Clair, provide a connecting channel between Lake Huron and Lake Erie. Areas in both the St. Clair and Detroit Rivers have been designated as Areas of Concerns under the Great Lakes Water Quality Agreement. A whole-water monitoring program for the St. Clair and Detroit Rivers was undertaken from 2001 thru 2006 to assess a wide range of organic and inorganic contaminants. The purposes of the survey was to identify contaminants of concern and to characterize their concentrations with a primary focus on upstream-downstream differences. Factors were calculated relating concentrations of analytes between sites across channel (Trenton vs Amhurstburg) and upstream downstream (St. Clair-Detroit R.). Dioxins and furans had a 15.5 increase down the corridor,chlorinated parrafins increased in concentration 6.8 times, polybrominated diphenyl ethers 26 times while the polychlorinated naphthalene increased >13000 times as measured at the Trenton Ch. Large volume water samples were also scanned by mass spectrometry to identify potentially unknown acontaminants of concern. *Keywords: PBDEs, Pesticides, Priority pollutants.*

CABRERA, A.R.[1], MORTSCH, L.D.[2], and DEADMAN, P.J.[1], [1]Dept. of Geography and Environmental Management, University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1; [2]Adaptation and Impacts Research Section, Climate Research Division, Environment Canada, c/o Faculty of Environment, University of Waterloo, Waterloo, ON, N2L 3G1. **Assessing Wetland Vegetation Response to Water Level Changes at the Long Point Wetland Complex, Lake Erie, Ontario.**

As part of the International Upper Great Lakes Study (IUGLS), Long Point was selected as a site to assess the impacts of the Lake Superior regulation plan and the impacts of climate change. A spatially explicit, rule-based model was used to explore the response of wetland vegetation communities to water level change - based on depth below or height above water, as well as the duration of hydrologic condition (flooded or exposed). The model was calibrated and verified against a database of wetland vegetation communities derived from analysis of ten air photos for the period of 1945-2006. Supervised calibration of the model improved cell-by-cell accuracy over previous efforts. Rules classify vegetation into one of six categories, including open water, exposed substrate, mixed emergent and floating vegetation, emergent vegetation, meadow marsh and treed/shrub areas. The model was used to explore the impact of multiple IUGLS water level scenarios on the distribution and abundance of wetland vegetation communities at Long Point. The modelling indicates that a decrease in area of emergent wetland vegetation is associated with higher water level or range compression scenarios.

Wetland vegetation community output from this model was used in the fish habitat assessment model for Long Point Bay (see Gertzen and Doka Abstract).
Keywords: Coastal wetlands, Lake Erie, Water level.

CABRERA, S.C.[1], BOEHME, S.E.[2], SMITH, E.R.[3], GOETTEL, R.G.[4], HALLESY, T.E.[4], KAMMIN, L.A.[4], and MCCARTNEY, A.[5], [1]Oak Ridge Institute for Science and Education/ U.S. EPA Great Lakes National Program Office, 77 W. Jackson Blvd. (G-17J), Chicago, IL, 60604; [2]Illinois-Indiana Sea Grant, 77 W. Jackson Blvd. (G-17J), Chicago, IL, 60604; [3]U.S. EPA Great Lakes National Program Office, 77 W. Jackson Blvd. (G-17J), Chicago, IL, 60604; [4]University of Illinois, 1101 W. Peabody Dr., Urbana, IL, 61801; [5]Pennsylvania Sea Grant, 301 Peninsula Dr., Suite 3, Erie, PA, 16505.
Unwanted Medicines and Educating our Communities: What Have we Learned, How are we Doing and What are the Next Steps?

Medicines are produced in increasing volumes every year. With this growth comes concern regarding environmental fate of unwanted medicines. Recent studies identified pharmaceutical compounds in fresh and marine waters nationwide, and several of these bioactive compounds are potentially harmful to aquatic organisms, even in small quantities. Additionally, improper medicine disposal poses poisoning risks to children, the elderly and pets, and can lead to drug/identity theft. Unused medicines may accumulate in homes or be flushed, placed in the trash, or given to others, all of which have significant disadvantages. One approach for decreasing amounts of unwanted medicines reaching the environment is through the utilization of educational tools and outreach programs that provide individuals with a rudimentary foundation on safer methods of disposal, in turn enabling them to take action in their own communities. This poster presentation will highlight the use and impacts of these tools and programs as well as analyze what our next steps should be to expand our efforts nationally.
Keywords: Environmental contaminants, Pharmaceuticals, Environmental education, Outreach.

CAMPBELL, L.M.[1], WANG, Y.X.[1], ZHONG, Y.[2], and RAZAVI, R.[1], [1]Department of Bioloy, Queen's University, Kingston, ON, K7L 3NP; [2]Department of Biodiversity, Fudan University, Shanghai, China. **Mercury biomagnification in selected Chinese lakes.**

China is one of the world's largest emitters of mercury. A survey of large lakes across eastern China and the Tibetan Plateau was carried out. Food web structure is assessed with stable isotopes of N and C. Mercury biomagnification in wild and farmed fish species is compared across the region. Finally, we discuss the implications for human and wildlife consumers of fish in both regions. *Keywords: Mercury, China, Stable isotopes, Asia, Biomagnification, Eutrophication.*

CAMPBELL, T.B. and TIEGS, S.D., Oakland University, 2200 N. Squirrel Road, Rochester, MI, MI, 48309. **Using Reach-Scale Variables to Predict the Abundance of the Round Goby (*Neogobius melanostomus*) in Tributaries of the Laurentian Great Lakes.**

Determining the distribution of round gobies and the characteristics of invaded streams are first steps toward effective management of their negative effects. We sampled 30 tributaries of the Great Lakes system throughout eastern Michigan, and each was characterized in terms of nine physical reach-scale attributes (e.g. stream width, mean particle size, velocity) and its fish community. Gobies were detected in 14 streams, with abundances ranging from 0% to 53% of the total fish sampled. Unpaired t-tests of stream attributes resulted in significant differences between goby-present and goby-absent streams, suggesting that there are differences between invaded streams. A principal-components analysis was then performed on the stream characteristic data, and the four extracted components regressed against goby abundance (as catch per unit effort [CPUE]). The only significant component was related to woody debris, canopy cover, community richness, and channel slope (p*Keywords: Invasive species, Round goby, Tributaries.*

CARAMBAS, M.C., 135 St. Clair Avenue West, 5th Floor, Toronto, ON, M4V 1P5.
Assessing the Economic Value of Investing in Great Lakes Protection: Implications for Environmental Policy and Management Decisions.

The net economic benefits of investing in Great Lakes protection are expected to be substantial. Great Lakes provide natural resources to support the regional economy, as well as amenities and services that are essential to the quality of life for the residents; benefits that are not adequately appreciated and valued in most environmental and economic decision-making. This study thus examines the cost-benefit analyses of selected intervention strategies, i.e. measures to prevent non-native species invasion, restore habitats or reduce nutrient flow, and discusses how the analytical findings could inform on-going environmental policy and management decisions. Cost-benefit analyses involve valuation based on benefits transfer method using studies employing varied valuation techniques, and demonstrate that returns on investment could average between 2:1 and 20:1 for different kinds of environmental interventions. This study shows that economic valuation of environmental improvements could help build a sound business case for investments in ecological restoration that also leads to economic restoration, identify the best opportunities when considering potential projects, programs and initiatives based on anticipated returns on investment, as well as enhance the general public's understanding of the Lakes' valuable services. *Keywords: Invasive species, Policy implications, Habitats, Green infrastructure, Economic evaluation.*

CARLSON-MAZUR, M.L.[1], LARSON, J.H.[2], RICHARDSON, W.B.[2], SCHAEFFER, J.[1], KOWALSKI, K.P.[1], SCHLOESSER, D.W.[1], ALLAN, J.D.[1], GAUGUSH, R.F.[2], FITZPATRICK, F.A.[3], SEELBACH, P.W.[1], and WAIDE, J.B.[2], [1]USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48015; [2]USGS Upper Midwest Environmental Sciences Center, 2630 Fanta Reed Road, La Crosse, WI, 54603; [3]USGS Wisconsin Water Science Center, 8505 Research Way, Middleton, WI, 53562. **Science for Effective Restoration of Rivermouth Ecosystems: Controls on Biophysical Structure and Food-Web Processes.**

Great Lakes rivermouth ecosystems are highly valued as urban, industrial, shipping, and recreational centers and are important spawning and nursery grounds for Great Lakes fishes. These places represent dynamic transition zones between riverine and lake processes where bidirectional mixing occurs. Despite the economic and ecological importance of rivermouth ecosystems, very little is known about their structure and function, which limits our ability to effectively manage and restore them. The goals of a recently initiated Great Lakes Restoration Initiative project are to examine biophysical and landscape controls on rivermouth structure and function at multiple spatial scales, and apply these findings in an improved scientific framework that will form the basis for restoration, management, and future research. To this end, we are studying rivermouth ecosystems to characterize their large-scale spatial structure using GIS, explore the hydrogeomorphic and habitat structure of rivermouths at local scales, and determine the structures and controls of food webs at both scales. A Great Lakes Rivermouth Collaboratory has been convened to develop a common science agenda that consolidates rivermouth knowledge and provides a framework for current and future research in support of restoration. *Keywords: Habitats, Estuaries, Coastal ecosystems.*

CARTER, G., RISENG, C.M., and ADLERSTEIN, S.A., 440 Church St, Ann Arbor, MI, 48109-1041. **Benthos population trends across the Great Lakes, 1997-2009.**

The U.S. EPA has monitored the benthos during the month of August at 10 to 16 stations in each of the five Laurentian Great Lakes since 1997. We examined trends in density, Oligochaete trophic indices, and Chironomid tolerance indices in each of the Great Lakes from 1997 through 2009. Total density in Lakes Michigan, Huron and Ontario declined over an order of magnitude primarily due to declines in *Diporeia* populations as has been shown in other studies. Trends in mean densities for major benthic taxonomic groups minus *Diporeia* and Dreissenids varied spatially by lake subbasin. Generally population densities declined in the southern basin of Lake Huron, the northern basin of Lake Michigan, and both east and west basins of Lake Ontario by an order of magnitude and increased in the central and west basins of Lake Erie, at least doubling the densities. Population densities were generally stable in the other lake subbasins. The Oligochaete Trophic Condition Index (TCI) suggests that the trophic status of Lakes Superior, Michigan, Huron and Ontario is oligotrophic and has not changed substantially during the past 12 years but there is a slight trend in Lake Erie toward increased eutrophication although the average TCI indicates a mesotrophic status. *Keywords: Amphipods, Indicators, Benthos.*

CASPER, G.S.[1] and HECNAR, S.J.[2], [1]Great Lakes Ecological Services, LLC, PO Box 375, Slinger, WI, 53086; [2]Lakehead University, Dept of Biology, 955 Oliver Rd, Thunder Bay, ON, P7B 5E1. **Coordinated Monitoring of Amphibians and Reptiles in the Lake Superior Basin.**

Development of effective monitoring programs is of fundamental importance in determining species status and documenting changes in their abundance and geographic distribution, especially in response to rapid climate change. Moreover, knowledge of the status of Lake Superior amphibians and reptiles is incomplete and lacks coordination. We tested the efficacy of six monitoring methods in sampling areas throughout the Lake Superior Basin. We conducted intensive surveys, over-sampling to obtain detection probability statistics for each method and species. This methodology allows for proportion-of-area-occupied modeling to correct for likely false negatives in occupancy, and can utilize data from existing, less robust, monitoring programs (i.e. calling frog surveys) for large scale analyses. We identified overlaps in methods for detecting species and made recommendations for achieving best return on effort for monitoring programs, including the minimum sampling effort required to achieve 95% confidence in detection. 21 species are readily detected (many by several methods), and detection probability varies widely among species, methods and periods with few significant differences among areas or habitats. We discuss current herpetofaunal monitoring in the basin and efforts underway to achieve basin-wide coordination among programs.
Keywords: Amphibians, Reptiles, Lake Superior, Habitats, Monitoring, Indicators.

CATALANO, M.J. and BENCE, J.R., Quantitative Fisheries Center, Michigan State University, East Lansing, MI, 48824. **The effects of ageing error on stock assessments for lake whitefish in Lake Huron.**

Age-structured fish stock assessment models are fitted to catch-age data and therefore ageing errors could influence management advice based on these methods. Lake whitefish populations within the U.S. waters of Lake Huron are managed for a total allowable catch (TAC) that is determined annually from an age-structured stock assessment model for each management unit. We evaluated the potential effect of ageing errors on these stock assessments and the resulting lake whitefish TACs. Ageing bias declined from an upward bias of 2 yrs for age-4 whitefish to a downward bias of 3 yrs for age-15 fish. Ageing precision decreased with age and ranged from a standard deviation of 0.75 to 1.5 yrs. Incorporating these ageing errors into the 2006 stock assessment for one of the management units resulted in a 25 to 68% decline in the TAC relative to a model that did not account for ageing errors. Less severe ageing bias and precision resulted in less reduction in the TAC. Further analyses will determine whether these findings are spatially (across management units) and temporally general. *Keywords: Computer models, Fisheries, Assessments.*

CHADDE, J.[1] and DANN, S.[2], [1]105 Dillman Hall-Michigan Tech Univ, 1400 Townsend Dr., Houghton, MI, 49913; [2]147B Natural Resources Bldg., Michigan State University, East Lansing, MI, 48824. **Great Lakes Stewardship through Teacher Leadership in Conservation Education.**

Great Lakes stewardship is accomplished through sustained teacher professional development, school-community partnerships, and student engagement in designing and implementing projects in their community. We examine teacher leadership as a strategy for connecting schools and communities in the stewardship of the Great Lakes and their watersheds. Teachers prepare K-12 students to become knowledgeable citizens, concerned about the Great Lakes, and actively engaged in stewardship activities that will contribute to the health, restoration, and future protection of the Great Lakes and their watersheds. In the Upper Peninsula of Michigan, we have engaged 7 school districts, 70 teachers, 1600 students and 45 community organizations in this work which includes 14 school-community projects in 3 counties. In mid-Michigan, 6 school districts, 30 teachers, 12 teacher leaders, and 1500 students have been involved in school-community watershed projects and Great Lakes stewardship. *Keywords: Education, Outreach, Watersheds.*

CHAFFIN, J.D.[1], BRIDGEMAN, T.B.[1], and BADE, D.L.[2], [1]Dept. of Environmental Sciences and Lake Erie Center, Univ. of Toledo, 6200 Bayshore Rd., Oregon, OH, 43616; [2]Dept. of Biological Sciences, Kent St. University, 256 Cunningham Hal, Kent, OH, 44242. **Seasonal Nitrogen Limitation in Western Lake Erie.**

In western Lake Erie (WLE), the total nitrogen (N) to total phosphorus (P) ratio decreases throughout the summer to values below 16, which would suggest N limitation and should favor N-fixing cyanobacteria. However, *Microcystis*, a non-N-fixing cyanobacterium, dominates WLE each summer, while N-fixing cyanobacteria are mostly absent. To determine if N limitation occurs in WLE, nutrient enrichment bioassays (P, N, N+P) were conducted on water collected from two locations throughout the summer 2010. In June and July, only treatments containing P increased phytoplankton growth, indicating P limitation. In August and September, enrichment with P and N resulted in the greatest growth rate, while enrichment of only P did not increase growth, indicating co-limitation. In a bioassay using only *Microcystis* from late August, only treatments containing N increased growth, indicating N limitation. Further, *Microcystis* tissue content of P and N showed deficiencies in both nutrients. *Anabaena* (a N-fixer) replaced *Microcystis* in September as nitrate was depleted. N-fixation potential rate of 0.6-0.8 μmol N /L/h was measured during the *Anabaena* bloom. The results of this study indicate that N can be limiting in late summer WLE, however, it is uncertain if N limitation occurs every year. *Keywords: Eutrophication, Microcystis, Nutrients.*

CHAFFIN, J.D. and STEPIEN, C.A., Lake Erie Center and Dept. of Environmental Sciences, Univ. of Toledo, 6200 Bayshore Rd., Oregon, OH, 43616. **Water Quality of Toledo Area Streams: Monitoring by Local High School Students with the help of University of Toledo Graduate Students.**

Our NSF funded, GK-12 program based at the University of Toledo's Lake Erie Center partners graduate students with high school teachers and their students. Through this program we aim to: 1) Generate student enthusiasm for science careers, 2) Exchange knowledge and pedagogies between graduate fellows and teachers, and 3) Develop hands-on solutions to environmental problems. Our graduate fellows facilitate and mentor independent research and science fair projects for high school participants, lead innovative, inquiry based lessons in the classroom, and connect students with nature by guiding them in water quality monitoring of schoolyard streams in conjunction with an existing, local Student Watershed Watch program. Students involved in the Student Watershed Watch collect and analyze water samples for chemical, biological, and physical parameters and use the data to calculate an overall water quality index value for their stream. The students use this index to directly compare water quality among the streams sampled and over time when they present their results at the annual Student Watershed Watch Summit. Program participants gain hands-on experience in the role of urban and agricultural influences on watersheds in the history, social development, and future vitality of the Great Lakes region. *Keywords: Watersheds, Education, Water quality.*

CHANG, F.C.[1], THOLSEN, T.M.[2], CRIMMINS, B.S.[3], HOPKE, P.K.[4], PAGANO, J.J.[5], and MILLIGAN, M.S.[6], [1]Dept.of Civil and Environmental Engineering, Clarkson University, Potsdam, NY, 13699; [2]Dept.of Civil and Environmental Engineering, Clarkson University, Potsdam, NY, 13699; [3]Center for Air Resources Engineering and Science, Clarkson University, Potsdam, NY, 13699; [4]Dept. of Chemical Engineering, Clarkson University, Potsdam, NY, 13699; [5]Environmental Research Center, 319 Piez Hall, SUNY at Oswego, Oswego, NY, 13126; [6]Department of Chemistry, SUNY at Fredonia, Fredonia, NY, 14063. **Temporal Trend Analysis of Polychlorinated Biphenyls and Organochlorine Pesticides in the Great Lake Fish, 1999-2009.**

Temporal trend analysis of the newest Great Lake Fish Monitoring and Surveillance Program (GLFMSP) data showed a statistically significant decrease of persistent bioaccumulative toxic contaminants in Lake Huron, Lake Ontario, and Lake Michigan over the 1999-2009 period. In contrast, trend analysis showed only minor fluctuations or relatively stable levels in Lake Superior and Lake Erie during the same period. A 5.0 ± 2.3% average annual decrease of polychlorinated biphenyl (PCB) concentrations occurred in all five lakes. Dichloro-diphenyl-trichlorethane (DDT) and its metabolites, dieldrin, and other organochlorine pesticides showed faster decreases, ranging from 8.4 ± 4.3% to 20 ± 7.1% per year. With the exception of PCB levels, this current decrease is greater than was shown by an earlier trends analysis which estimated an annual contaminant decrease of about 2-5% for the 1980-2003 period. Decreases in PCB concentrations in other media (water, air, and herring gull eggs) in the Great Lakes

were also faster in this earlier period than seen in more recent observations. Rates of change in concentrations for other organochlorine pesticides will also be presented.
Keywords: Great Lake Fish, Temporal Trend Analysis, PBT.

CHAPRA, S.C.[1] and DOLAN, D.M.[2], [1]Tufts University, Civil and Environmental Engineering, Medford, MA, 02155; [2]University of Wisconsin - Green Bay, Natural and Applied Sciences, Green Bay, WI, 54311. **Great Lakes Total Phosphorus Model: Post-Audit.**

Thirty years ago, a total phosphorus model was developed to establish phosphorus loading targets for the 1978 Great Lakes Water Quality Agreement. The present talk employs up-to-date loading measurements to evaluate whether the model adequately simulates recent water-quality improvements. Simulation results for the upper Great Lakes exhibit reduced TP concentrations following load reductions that have occurred since the mid-1970s. Although it is clear that all three upper lakes are now solidly oligotrophic if not ultraoligotrophic, Green Bay and Saginaw Bay are currently not meeting guidelines/targets. Simulation results for the three basins of Lake Erie exhibit significant improvement following load reductions. However, the levels still remain above the goals of mesotrophy for the Western basin and oligomesotrophy for the Central and Eastern basins. Results for Lake Ontario exhibit significant reductions following load reductions. However, the observations indicate that the lake has improved more than predicted by the model. Whereas the model predicts that the load reductions should bring the lake to the oligomesotrophic target levels, the data suggests that it is solidly oligotrophic and seems to be approaching the ultraoligotrophic state of the upper lakes.
Keywords: Phosphorus, Mass balance, Model studies.

CHENG, P. and AUSTIN, J.A., Large Lakes Observatory, U. M. Duluth, Duluth, MN, 55812, USA. **Seasonal dependence in the response of lake water temperatures to atmospheric warming.**

The thermal response of lakes to air temperature highly depends on their mixing behavior. Stratification impacts vertical heat transfer in the water column of a lake, resulting in different response of water temperatures to atmospheric warming. We conducted a series of numerical experiments with an idealized monomictic lake. Two-month air temperature perturbations were added during well-mixed and stratified seasons of the lake respectively. Responding to a seasonal increase in air temperature, the surface water temperature increases during the warming period, then decreases exponentially in the following seasons. The maximum increase in surface water temperature is proportional to the change of air temperature during the well-mixed season, and is dependent on the thickness of epilimnion during the stratified season. The time scale of the indirect influence on the following seasons is determined by heat exchange between the atmosphere and lake. During the well-mixed period, atmospheric warming enhances the heat content of the entire water column and has a long-term influence on the lower water column in the following seasons, while during the stratified period the influences of

atmospheric warming are largely restricted to the epilimnion, and are insignificant in the following seasons. *Keywords: Climate change, Air-water interfaces, Computer models.*

CHIOTTI, J.[1], FRANCIS, J.[2], BOASE, J.C.[1], THOMAS, M.V.[3], MANNY, B.A.[4], and ROSEMAN, E.F.[4], [1]Alpena Fish and Wildlife Conservation Office, Waterford Substation, 7806 Gale Rd., Waterford, MI, 48327; [2]Michigan Department of Natural Resources, Fisheries Division, 26000 Eight Mile Rd., Southfield, MI, 48034; [3]Michigan Department of Natural Resources, Mount Clemens Fisheries Research St., 33135 South River Rd., Mount Clemens, MI, 48045; [4]USGS Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105; **Comparing Fish Communities Among Different Wetland Types within the Huron-Erie River Corridor.**

Fish communities were compared between wetland types in the Huron-Erie Corridor using day and night electrofishing, fyke nets, and seining in 2004-2008. Wetland types included delta (St. Clair Flats), lacustrine embayment (N. Maumee Bay), connecting channel (Detroit R.), and drowned river mouth (Huron R. and Swan Ck. estuaries). Species richness was greatest in the St. Clair Flats (56 species). 41, 54, and 51 species were captured at the Detroit R. in 2004, 2006 and 2008. 38 species were captured at Swan Ck. Estuary, 37 in the Huron River Estuary, and 35 in North Maumee Bay. Cyprinids and Atherinids were the dominant families in the St. Clair Flats composing 81% of the catch. Catches in the Detroit R. varied by year. Cyprinids composed between 42-62% of the catch each year, Centrarchids, Catostomids, Percidae, and Gobies contributed to catches dependent upon year. Moronids, Centrarchids, and Clupeids composed 71% of the catch in N. Maumee Bay. Huron R. and Swan Ck. estuaries were dominated by Centrarchids, Cyprinids, and Clupeid composing 76 and 88% of the catch. Preliminary analyses suggest similar composition between riverine and connecting channel wetlands containing mainly Cyprinids. The lacustrine embayments and drowned river mouths contained lower diversity and greater composition of Centrarchids and Clupeids. *Keywords: Coastal ecosystems, Wetlands, Detroit River, Juvenile fish, St. Clair River.*

CHIRIBOGA, E.D., Great Lakes Indian Fish and Wildlife Commission, 550 Babcock Dr. Rm. B-102, Madison, WI, 53706. **Mapping Mining Activity in the Lake Superior Basin.**

In recent years, the demand for metals around the world and the resulting high prices have been driving exploration and development of mining projects in the mineral-rich Lake Superior basin. The Great Lakes Indian Fish and Wildlife Commission has been developing and maintaining Geographic Information System (GIS) databases of mineral activity in the western Great Lakes region for the past 12 years. As part of GLIFWC's work with the Binational Program to Restore and Protect Lake Superior, GLIFWC has expanded this work to include the Canadian portion of the watershed. As a result, GLIFWC is able to provide detailed spatial representations of mining activity at multiple spatial scales. These representations can then be used to define areas potentially

impacted by both individual mines and mining districts composed of multiple mines.
Keywords: GIS, Mining.

CHOMICKI, K.M.[1], HOWELL, E.T.[2], and TAYLOR, W.D.[1], [1]University of Waterloo, 200 University Ave W, Waterloo, ON, N2L 3G1; [2]Ontario Ministry of the Environment, 125 Resources Road, Toronto, ON, M9P 3V6. **Land Use, River Influences, and Water Quality at Contrasting Sites Along Nearshore Regions of the Great Lakes.**

Rivers are important influences on nearshore water quality in the Great Lakes. However, measuring the degree and extent of their influence is difficult because of temporal variability in discharge and river water quality, as well as spatial and temporal variability in the nearshore zone independent of river influences. In this work, we observed river influences on 17 nearshore sites, most of which were located along the northern shores of Lakes Erie, Ontario, and Superior. Draining into each of these regions were rivers of varying size and catchment land use. Using ship and shoreline continuous monitoring, we measured NO3+NO2, turbidity, chl a, conductivity and UV fluorescence to visualize river water entering the nearshore. Conductivity-weighted and spatially-weighted nutrient concentrations were computed to compare the different sites. Conductivity-weighted TP and NO3+NO2 ranged from 5-92 μg P/L and from 59-1140 μg N/L, respectively. Spatially-weighted conductivity and chl a ranged from 103-393 μS/cm and 0.1-22 μg/L, respectively. These weighted concentrations allowed the nearshore zones to be characterized by a single value. Using weighted concentrations, spatial and temporal features of nearshore water quality were compared and relationships between land use, river influences, and water quality were explored.
Keywords: Nutrients, Water quality, Monitoring.

CHU, C.[1], KOOPS, M.A.[2], and RANDALL, R.G.[2], [1]Nature Conservancy of Canada/Fisheries and Oceans Canada, 2140 East Bank Drive, Peterborough, ON, K9J 7B8; [2]Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Ecological modelling and management: insights from Lake Ontario.**

Lake Ontario management objectives have changed in response to changing conditions in the Lake through time. In the 1960s and 1970s, management efforts focused on water quality. In the 1980s and 1990s sea lamprey control, lake trout (Salvelinus namaycush) rehabilitation and development of the salmonid fishery were paramount while the main issues from the 2000s to present have been invasive species, cumulative stressors and climate change. The objectives of this study were to summarize the different ecological models that have been developed to address these objectives, and synthesize the insights that may be learned from those efforts. The models include empirical relationships among a few target variables, physical hydrodynamic models, lower trophic food web models, whole-lake food web bioenergetic models, age-structured population models, mass-balance models and coupled physical and biological models. There has been a shift from single species or single-objective models to more complex ecosystem-

based models as researchers and managers realize that the former models inadequately capture ecosystem change. These more complex models also provide a framework for incorporating and assessing the potential impacts of emerging issues. Modelling efforts in Lake Ontario provide a frame of reference for efforts in the Upper Great Lakes.
Keywords: Ecosystem modeling, Model studies, Lake Ontario.

CIBOROWSKI, J.J.[1], BRADY, V.J.[2], JOHNSON, L.B.[2], GATHMAN, J.P.[3], BRENEMAN, D.[2], HOLLAND, J.[4], and BHAGAT, Y.[5], [1]Dept of Biological Sciences, University of Windsor, Windsor, ON, N9B3P4; [2]University of Minnesota Duluth, Natural Resources Research Institute, Duluth, MN, 55811; [3]Department of Biology, University of Wisconsin - River Falls, River Falls, WI, 54022; [4]Department of Entomology, Purdue University, West Lafayette, IN, 47907; [5]Annis Water Resources Institute, Grand Valley State University, Muskegon, MI, 49441. **Zoobenthic bioindicators of environmental condition at Great Lakes Coastal Areas: A comparison of methods.**

We compared the effectiveness of a suite of multimetric and multivariate methods for deriving zoobenthic indicators of changing anthropogenic stress intensity in various type of Great Lakes coastal margin habitats. Narrow habitat preference and variation in distribution across biogeographic provinces necessitated development of lake- and habitat-specific metrics. Multivariate approaches generally outperformed multimetric methods of ordinating zoobenthic measures across stress gradients.
Keywords: Bioindicators, Zoobenthos, Environmental effects.

CLARK, G.R.[1], ANDERSON, J.D.[2], KRUMENAKER, R.J.[3], and WU, C.H.[2], [1]University of Wisconsin Sea Grant Institute, Lake Superior Field Office, 153 Hawkes Hall, Superior, WI, 54880; [2]University of Wisconsin Dept of Civil & Environmental Engr., 1269D Engineering Hall, Madison, WI, 53706; [3]Apostle Islands National Lakeshore, 415 Washington Ave, Bayfield, WI, 54814. **Design & Implementation of a Real Time Wave Observation System (RTWOS) at the Apostle Islands Mainland Sea Caves.**

The Apostle Islands National Lakeshore Mainland sea caves are spectacular natural rock cave formations of the exposed sandstone cliffs. They are a world-class destination for kayaking. However, they can also be very dangerous. When waves encounter the region, wave processes can produce unexpected extremely high wave heights near the scooped-out hollows in the sea cave areas. Kayakers are warned to avoid the area during rough seas. However, unexpected high waves can capsize boats or kayaks, leaving little opportunity for kayakers to respond. Fatalities may be prevented by the implementation of a RTWOS. The RTWOS was designed and testing completed in 2010. Using wireless cellular technology, the system has successfully sampled and transmitted wave data to the host computer at UW-Madison which displayed the processed data to a real time assessable web page. Scheduled to go on-line in Spring 2012, real-time wave height information from this remote sea cave location will be accessible anywhere, and visiting sea cave visitors will be better informed concerning the

potential dangerous wave and water temperature conditions at the site. The project management plan includes public safety and web access training providing outreach of public awareness of the potentially dangerous wave conditions and how to access the real-time information. *Keywords: Data acquisition, Waves, Coastal processes, Monitoring, Lake Superior.*

CLARK, G.R.[1], BOWMAN, D.W.[2], SHARROW, J.D.[3], BROSSART, S.J.[5], and SERCK, J.L.[4], [1]University of Wisconsin Sea Grant Institute, Lake Superior Field Office, 153 Hawkes Hall, Superior, WI, 54880; [2]US Army Corps of Engineers, P.O. Box 1027, Detroit, MI, 48231; [3]Duluth Seaway Port Authority, 1200 Port Terminal Drive, Duluth, MN, 55802; [4]City of Superior Port Director, 1316 N. 16th St., Superior, WI, 54880; [5]US Army Corps of Engineers - Duluth Office, 600 Lake Ave South, Duluth, MN, 55802.
Duluth-Superior Harbor Beneficial Use of Dredged Material Efforts at Erie Pier.

The port of Duluth/Superior is the largest port on the Great Lakes in total cargo volume and critical to the local and regional economy. To maintain the miles of commercial maritime transportation channels open, the US Army Corps of Engineers must annually dredge 100,000 - 125,000 cy of channel deposits. Historically, approx. 100,000 cy per year has been placed at the Erie Pier Confined Disposal Facility (CDF) which was constructed in 1979. Erie Pier's useful life is estimated to be only another four years. Therefore, critical steps had to be undertaken to insure dredging could continue and the valuable maritime commerce channels would remain open. A management plan was completed in 2007 and significant efforts to beneficially use the material in a sustainable way have been underway to extend its life indefinitely. Efforts include major renovations to transform the CDF into a Processing and Reuse Facility (PRF), separating and stockpiling material for beneficial use, contracts with local contractors to use the material in construction projects, demonstration projects utilizing the material for mineland reclamation, working towards permitting material as local landfill cover material, significant material testing to insure it meets or exceeds designated standards,and public education that the material is a valuable resource.
Keywords: Dredged Material, Beneficial Use, Lake Superior, Commercial Maritime Navigation.

CLEMENT, T.A., MURRY, B.A., and UZARSKI, D.G., Institute of Great Lakes Research, CMU Biological Station on Beaver Island, Department of Biology, Central Michigan University, Mount Pleasant, MI, 48859. **Size Structure of Small Lake Fish Assemblages: The Role of Lake Size, Biodiversity, and Disturbance.**

The size structure of aquatic communities is highly predictable. Generally organism abundance decreases with increasing body size, however, the vast majority of work in this area has been conducted in large aquatic systems with relatively few studies conducted on small lakes (>200 ha). We studied the size structure of the fish assemblages of six small lakes on Beaver Island, northern Lake Michigan. The lakes are relatively pristine with predominately undeveloped watersheds. Four of the six lakes surveyed

showed a deterministic size structure (slopes -0.68 to -0.92) while two lakes did not. Lake size (14 - 192 ha) and species richness (8 - 22 species) differed among the lakes with deterministic size structure, but all four lakes had relatively stable environmental conditions. In contrast, the two lakes that did not show a predictable slope were moderately sized (8 and 24 ha), had low biodiversity (4 and 2 species), and were subject to periodic winterkill and summer drought. Low biodiversity and/or high disturbance regime appear to limit the development of deterministic size structure. The slope of the size distribution was negatively related to lake size. Our finding of predictable size structure in small lakes adds a new dimension to the growing data set of size structured communities and their limits. *Keywords: Biodiversity, Size Spectra, Size structure, Fish.*

CLITES, A.H., HUNTER, T., GRONEWOLD, A.D., and STOW, C.A., NOAA/Great Lakes Environmental Research Laboratory, 4840 S. State Rd, Ann Arbor, MI, 48108.
An Appraisal of the Great Lakes Advanced Hydrologic Prediction System.

The National Oceanic and Atmospheric Administration Great Lakes Environmental Research Laboratory (GLERL) helped lay the foundation for probabilistic forecasting of water levels with the development of its Large Basin Runoff Model in the 1980's and Great Lakes Advanced Hydrologic Prediction System (AHPS) in the mid 1990's. Further calibration of these tools has the potential to improve their performance. Choosing between different forecasts in support of a management decision should be based, at least in part, on the relative performance of the model over time. However, we find that current literature includes few assessments of model skill over various temporal scales and within a probabilistic framework. To help address this gap, we compared observed and modeled water levels using a "hind cast" meteorological data set constructed for the period 1997 through 2008. We documented the frequency with which observations fell within 90% prediction intervals for both three and six-month forecasts. Our results indicate that 90% prediction intervals contained the observed value from 63 to 72% of the time, suggesting that AHPS is a robust and valuable tool for understanding how climate patterns, land use change, and lake regulations plans might affect future lake level dynamics. *Keywords: Model testing, Water level fluctuations, Hydrologic cycle.*

COLTON, M.C., NOAA Great Lakes Environmental Research Laboratory, 4840 South State Rd., Ann Arbor, MI, 48108. **GLERL's Great Lakes Climate Change Program.**

Great Lakes climate change is the major driver to other subsystems: hydrodynamics, lake ice, ecosystems, and surface hydrology. The impacts of large-scale climate teleconnection patterns have significant signature in the regional Great Lakes scales. The National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Laboratory (GLERL) is conducting the climate change program that focuses on the regional climate change in response to the large-scale, hemispheric climate patterns, such as ENSO (El Nino and South Oscillation) and Arctic Oscillation (AO) or North Atlantic Oscillation (NAO), with the help of data analyses and modeling. Some important findings will be addressed based on our analyses. Furthermore, the

coupled regional climate model and coupled ice-circulation model are being developed at GLERL over the entire five Great Lakes watershed scale. The capability of these coupled models enables us to simulate the regional climate response to large-scale climate change, and to project the future scenarios in the Great Lakes. *Keywords: Great Lakes basin, Climate change.*

COOPER, M.J.[1], MURRY, B.A.[2], and UZARSKI, D.G.[3], [1]Department of Biological Sciences, University of Notre Dame, Notre Dame, IN, 46556; [2]Department of Biology, Central Michigan University, Mount Pleasant, MI, 48859; [3]Institute for Great Lakes Research, Central Michigan University, Mount Pleasant, MI, 48859. **Potential Impacts of Great Lakes Water Level Management on Coastal Wetland Fish and Macroinvertebrate Communities.**

Wetland fauna are affected by hydrology both directly (e.g., by currents, flows, and flooding) and indirectly via the effects on wetland vegetation. Here we focus on the indirect effects for fish and macroinvertebrates and identify potential consequences of wetland contraction and shifts from *Schoenoplectus* spp. to *Typha* spp. that may occur under certain water level management scenarios. We analyzed faunal data collected in coastal wetlands of Lakes Huron and Michigan from 2000 to 2008. In *Schoenoplectus* wetlands, total macroinvertebrate density was significantly higher in vegetated (44.9±12.8 organisms m^{-2} than in unvegetated (14.0±3.9 organisms m^{-2}) patches and taxon richness was significantly higher in vegetated (18.7±1.0) than unvegetated (8.8±1.1) patches. In *Nuphar* wetlands macroinvertebrate taxon richness was significantly higher in vegetated (16.4±1.0) than unvegetated (8.9±0.2) patches. Fish species richness and abundance were both significantly lower in *Typha* than *Schoenoplectus*. Our results suggest that water level management decisions that cause wetland contraction or shifts toward *Typha*-dominance could have profound impacts on coastal wetland macroinvertebrate and fish communities. *Keywords: Coastal wetlands, Water level fluctuations, Macroinvertebrates.*

CORKUM, L.D.[1], DAWSON, T.[1], GLASS, W.[1], RAASCH, K.B.[1], and YAVNO, S.[2], [1]Department of Biological Sciences, Univesrity of Windsor, Windsor, ON, N9B 3P4; [2]Environmental & Life Sciences, Trent University, Peterborough, ON, K9J 7B8. **Round Goby Nest Preference and Egg Odour Attraction.**

The round goby is a successful invader, owing to its breeding habits. Males guard and maintain eggs in nests. When parental males leave nests to chase intruders, conspecifics enter nests and eat eggs. Earlier, we showed that non-reproductive adult females were attracted to reproductive female odours, suggesting egg odours were attractants. Egg odours may be attractants and cannibalism could be adaptive if food was limiting. We tested nest preferences of parental males in Lake Erie. We repeatedly deployed 75 PVC tube nests and 40 box nests (2 sizes: 15 cm x 15 cm and 30 cm x 30 cm) with small (3 cm x 3 cm) and large (6 cm x cm) openings from May to August. Males selected nests with small rather than large openings regardless of nest size.

Reproductive success (surface area of eggs in nests) was positively related to male size. Using a lab flume, we showed that juvenile and adult (reproductive and non-reproductive) female round goby exhibited no preference between conspecific and heterospecific (rainbow trout) egg odours when food was withheld. With food, only juveniles preferred conspecifc rather than heterospecific egg odours ($P<0.05$). The notion that non-reproductive females track reproductive females because of egg odours is rejected. Other explanations for the tracking may be linked to copying nest and/or mate choice. *Keywords: Invasive species, Fish behavior, Round goby.*

CRADDOCK, M.L.[1], MURPHY, E.W.[2], NETTESHEIM, T.[2], and BACKUS, S.M.[3], [1]Oak Ridge Institute for Science and Education, 77 West Jackson Boulevard (G-17J), Chicago, IL, 60604; [2]U.S. Environmental Protection Agency, 77 West Jackson Boulevard (G-17J), Chicago, IL, 60604; [3]Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Increasing Partnerships and Collaboration on Great Lakes Emerging/Emerged Contaminant Research.**

While concentrations of legacy contaminants in the Great Lakes have generally declined, many emerging and emerged contaminants have only recently been identified and measured in the Great Lakes. As monitoring programs and researchers move forward in understanding the presence and distribution of these contaminants it is important to emphasize collaboration and shared resources. A matrix of analyte information, availability of standards and sample site locations has been created to identify areas of overlap for potential collaboration between US EPA and Environment Canada monitoring programs. This talk will examine ways to improve collaboration and increase knowledge of emerging contaminants such as inter-laboratory studies, sharing of standards, alerting other monitoring programs when emerging contaminants are detected and coordinated sample site selection to get a top to bottom look at contaminants. The importance of communication of results to other monitoring programs and management agencies will also be emphasized. This sharing of information will result in a better and more complete understanding of the state of emerging contaminants in the Great Lakes and allow for the incorporation of these contaminants into other monitoring programs as well as management decisions. *Keywords: Monitoring, Planning, Environmental contaminants.*

CRAIG, J.M.[1], KENNEDY, G.W.[1], ROSEMAN, E.F.[1], BOASE, J.C.[2], and HONDORP, D.W.[1], [1]US Geological Survey - Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105; [2]U.S. Fish and Wildlife Service, Alpena FWCO - Waterford Substation, 7806 Gale Rd., Waterford, MI, 48327. **Factors Affecting the Distribution and Species Composition of Spawning by Several Fish Species in the Detroit and St. Clair Rivers.**

As part of fish habitat remediation efforts, we evaluated the extent of fish spawning in the Detroit and St. Clair rivers using egg mats. Objectives included assessing the location, phenology, and density of fish eggs on spawning areas in these Great Lakes connecting channels, focusing on broadcast spawners such as lake sturgeon, walleye, lake whitefish, and several sucker species. Egg mats were set throughout both rivers during the spring and fall spawning periods. The Detroit River was sampled in 2007 - 2008, with the St. Clair sampled in 2010. Walleye were the predominant spawners in both river systems. Sucker eggs were collected at fewer locations and found mostly in gravelly areas. Whitefish eggs were collected primarily within the lower half of the Detroit River and were absent in the St. Clair River. Sturgeon deposited eggs only on specific reef areas primarily in the St. Clair River although spawning has occurred at a newly constructed reef in the Detroit River (2009-2010). Although these rivers are similar both geographically, morphologically, and hydrologically connected, it appears that subtle differences, such as location to adjacent Great Lakes water bodies, appear to influence fish spawning habits. Work will continue through 2011 to describe the subtle habitat characteristics between these rivers. *Keywords: Bottom sampling, Fish Spawning, Coastal ecosystems, Rivers, Habitats.*

CREECH, C.T., SELEGEAN, J.P., and DAHL, T.A., US Army Corps of Engineers, 477 Michigan Ave, Detroit, MI, 48226. **Reducing Sediment Yields to Lake Superior: Case Studies from the Great Lakes Tributary Modeling Program.**

The U.S. Army Corps of Engineers has a congressional mandate to develop tools designed to assist local stakeholders in managing sediments in watersheds that drain to federal harbors or Areas of Concern within the United States portion of the Laurentian Great Lakes. Much of the original efforts of this program have focused on the agricultural-dominated watersheds of Lakes Michigan-Huron, Erie, and Ontario; however, many recently developed models have addressed the sediment issues within the predominately forested Lake Superior tributary watersheds. Several models have been developed that quantify sediment impacts associated with these forestry practices (clear cutting, logging roads, etc) and prioritize the locations of Best Management Practices. Other models focused on the geologic history of natural sediment loads throughout the Holocene in the geologically young lacustrine watersheds of Michigan's Western Upper Peninsula. Still other models have been used to prioritize stream restoration scenarios that maximize sediment load reductions to Lake Superior. This presentation will specifically showcase four diverse models that were developed in the previous year within the following Lake Superior Watersheds: Ontonagon River, MI; Siskiwit River, WI; Whittlesey Creek, WI; and Knife River, MN. *Keywords: Lake Superior, Tributary modeling, Sediment load, Sediment transport.*

CRIGER, L.A., U.S. Fish and Wildlife Service, 3090 Wright Street, Marquette, MI, 49855. **An Overview of Recent Advances in the Integrated Management Program for Controlling Sea Lampreys in the Great Lakes.**

Many improvements have been incorporated into the integrated pest management program to suppress sea lamprey (Petromyzon marinus) in the Great Lakes. Assessments to estimate larval sea lamprey abundance have transitioned from using a quantitative assessment approach to a rapid assessment technique which allocates more resources to conducting lampricide treatments and identifying new sources of sea lamprey production. Stream treatment effort has increased not only by the number of streams treated with lampricides, but also by implementing enhanced treatment strategies to maximize treatment efficacy. Other lampricide control efforts include treating infested lentic areas and completing consecutive treatments to reduce potential sources of residual populations of larval sea lamprey. Barriers continue to be a significant alternative control technology by reducing spawning potential of sea lamprey; however, emphasis has shifted from constructing new barriers to maintaining and improving existing barriers. Other alternative control strategies include trapping spawning-phase sea lamprey and the sterile male release technique, both which have become more effective by modifying trap designs. In addition, research has been conducted on the use of pheromones to alter the migratory behavior of spawning-phase sea lamprey. *Keywords: Invasive species, Sea lamprey, Pesticides, Great Lakes, Exotic species.*

CRIMMINS, B.S.[1], XIA, X.[1], PAGANO, J.J.[2], MILLIGAN, M.S.[3], HOPKE, P.K.[1], and HOLSEN, T.M.[1], [1]Clarkson University, Potsdam, NY; [2]SUNY Oswego, Oswego, NY; [3]SUNY Fredonia, Fredonia, NY. **Perfluoroalkylated compounds (PFCs) in Great Lakes Fish as part of the Great Lakes fish Monitoring and Surveillance Program (GLFMSP).**

The Great Lakes Fish Monitoring and Surveillance Program (GLFMSP) was recently tasked with exploring non-legacy contaminant distributions in the Great Lakes' top predators. Perfluoroalkylated compounds are one such class of compounds that has received increased attention in the last decade. Previous quantifications have been hindered by interferences, ion suppression and lack of a comprehensive quantitation and recovery standards. Interlaboratory comparisons have also shown significant variability among laboratories and procedures. While there is typically a trade-off between instrument sensitivity, specificity and quantitative linearity we have developed a method for PFCs using newly developed UPLC-QTOF technology addressing each of these concerns. The current platform describes the methodology, instrumentation specifications and performance evaluation for current and future PFC analysis of Great Lakes' biota.
Keywords: PFOs, Lake trout.

CRIMMINS, B.S.[1], PAGANO, J.J.[2], XIA, X.[1], MILLIGAN, M.S.[3], HOPKE, P.K.[1], and HOLSEN, T.M.[1], [1]Clarkson University, Potsdam, NY; [2]SUNY Oswego, Oswego, NY; [3]SUNY Fredonia, Fredonia, NY. **Polybrominated diphenyl ethers (PBDEs) in Great Lakes lake trout: Turning the corner in the Great Lakes Region 1980 -2008.**

Lake trout and walleye composites, collected between 2004 and 2008 as part of the Great Lakes Fish Monitoring Program (GLFMP), were analyzed for polybrominated diphenyl ethers (PBDEs). Yearly mean total PBDE concentrations (sum congeners 47, 99, 100, 153, 154, wet weight) ranged from 50 - 114, 28 - 68, 50-78, 37 - 90 and 6.7 - 17 ng/g for Lakes Michigan, Huron, Ontario and Superior lake trout, and Erie walleye,

respectively. A 1980-2008 temporal record of PBDE concentrations was assembled by integrating previous GLFMP data (1980-2003) with the current results. Temporal profiles show obvious breakpoints between trout accumulation and depuration periods for Lakes Huron, Michigan and Ontario with in a significant decrease in concentration after 2000-2001. A similar shift was observed in Lake Superior with an insignificant depuration slope, suggesting concentrations in this lake are declining very slowly or have leveled off. In contrast, Lake Erie exhibited an increase in PBDE concentrations from 2005-2008. This study provides the first region-wide evidence that PBDE concentrations are generally declining in the Great Lakes although there are clear exceptions to this trend. Results from this study appear to reflect the positive effect that the 2004 PentaBDE ban has had on macro- scale aquatic freshwater ecosystems. *Keywords: PBDEs, Lake trout.*

CROUSE, A.B., AXLER, R.P., HOST, G.E., BROWN, T.N., ERICKSON, J.M., and JOHNSON, L.B., Natural Resources Research Institute, 5013 Miller Trunk Highway, Duluth, MN, 55811. **Land Use/Land Cover and Hydrologic Effects on North Shore Superior Tributary Water Quality.**

Streams along the North Shore of Lake Superior face increasing developmental pressures and, thus far, remain relatively pristine, although some are already listed as impaired. Although a few studies have explored interactions between landscape and water quality much of the variability remains unexplained. Using GIS analyses of landscape characteristics of 30 North Shore watersheds coupled with meteorological data and a compilation of the water chemistry data set that has greatly expanded in the past decade, we developed empirical models using multivariate and multiple regression analyses that better explain the variability of water quality data and allow quantification of relationships among these data sets. The ultimate goal of this project is to provide tools for forecasting the impacts of land use decisions on water quality with known accuracy. *Keywords: Climatic data, Watersheds, GIS.*

CUDMORE, B., Fisheries and Oceans Canada, 867 Lakeshore Rd., Burlington, ON, L7R 4A6. **Pathway History of Non-Native Fish Introductions in the Great Lakes.**

Over the last 200 years, the fish fauna of the North American Great Lakes has changed significantly as a result, in part, of the introduction of non-native fishes. These species have been introduced through a variety of pathways including commercial shipping, dispersal, live trade, recreational boating and angling, and stocking. These pathways have resulted in the successful introduction and establishment of 35 non-native fish species. In addition, 34 non-native species have been found in the basin, but are not thought to have established reproducing populations. The relative importance of pathways as a source of new introductions has changed over time, and can be expected to continue to change as a result of evolving regulations and trade patterns.
Keywords: Invasive species, Great Lakes basin, Fish.

CUDNEY, K.A.[1], JANIK, C.E.[1], and PENNUTO, C.M.[2], [1]Biology Department, Buffalo State College, Buffalo, NY, 14222; [2]Great Lakes Center, Buffalo State College, Buffalo, NY, 14222. **The Effects of the Invasive Round Goby (*Neogobius melanostomus*) on Organic Matter Processing: a Mesocosm and Field Test.**

In recent years, the round goby has established itself in tributaries to the Great Lakes, significantly impacting benthic fish and invertebrate communities. If round gobies reduce invertebrate shredders in heterotrophic streams, they could prevent the breakdown of leaf-litter course particulate organic matter (CPOM), limiting energy to downstream reaches. We investigated a round goby-mediated trophic cascade on detritus dynamics by coupling observations at goby-present and goby-absent locations in a local stream with a mesocosm experiment. The field study showed significant reductions in CPOM breakdown in reaches with round gobies versus goby-absent reaches. Shredders dominated leafpacks in goby-absent reaches, and were virtually absent in goby-present reaches. The mesocosm study resulted in no differences in leaf-breakdown rates between goby-present and goby-absent treatments, but there were significant treatment effects on amphipod abundance ($p=0.008$). There was no difference in snail abundance or size, or in amphipod size between treatments. Our study provides evidence that this invasive predator may be influencing resource dynamics in donor-controlled food webs through effects on consumers (field study), but that Great Lakes organic matter processing is controlled less by amphipods and snails than other community members.
Keywords: Round goby, Trophic cascade, Invasive species, Leaf breakdown, Tributaries.

CZESNY, S.J.[1], RINCHARD, J.[2], and HANSON, D.[3], [1]Lake Michigan Biological Station, 400 17th street, Zion, IL, 60099; [2]The College at Brockport - State University of New York, 390 New Campus Drive, Brockport, NY, 14420; [3]U.S. Fish and Wildlife Service Green Bay Fish & Wildlife Conservation Office, 2661 Scott Tower Dr., New Franken, WI, 54229. **Does spatiotemporally variable prey base in the Great Lakes affect lake trout egg fatty acid signatures?**

Prey fish assemblages vary substantially among the Great Lakes as each ecosystem constitutes an inimitable community and has management strategies adapted to the particulars of its fisheries and conservation needs. Within each system there are also considerable temporal fluctuations in prey assemblage as native and nonnative species undergo sizable abundance oscillations. Thus the nutrients available to top predators utilizing a dynamic prey base vary spatiotemporally. Predators' tissues, including eggs, can reflect such changes in nutrient intake. We analyzed fatty acid signatures of lake trout eggs from multiple Great Lakes in a single year and from Lake Michigan in multiple years to document the amount of variability one can expect on the spatial and temporal scales, respectively. Eggs from various lakes could be readily distinguished based on their fatty acid signatures, although the degree of difference varied among systems. Within Lake Michigan, lake trout egg fatty acid signatures were also variable and grouped based on year of sampling. These results are indicative of large variation in lake trout egg fatty acid signatures among and within the Great Lakes. We will discuss these results in the context of fluctuating prey assemblages and reflect on

potential ramifications for lake trout egg quality. *Keywords: Lake trout, Fatty acids, Great Lakes basin, Eggs, Fish diets.*

CZYPINSKI, G.D.[1], NEMEC, R.[2], JABLONSKI, V.[2], and REARDON, C.J.[2], [1]U.S. Fish & Wildlife Service, 2800 Lakeshore Drive East, Suite B, Ashland, WI, 54806; [2]Ashland High School, 1900 Beaser Ave., Ashland, WI, 54806. **Cost Effective Early Detection Monitoring for Invasive Mollusks and Fish.**

In the past, the establishment of zebra mussels (Dreissena polymorpha) in Chequamegon Bay, a popular 39,520 acre embayment in southwestern Lake Superior, has been unsuccessful due to the low calcium (< 20 ppm) content of Lake Superior waters. However, transient vessel traffic from the Duluth-Superior harbor, 112 km west of Chequamegon Bay, which has established populations of invasive mollusks and fish, and global warming, could lead to introduction of these invasives into Chequamegon Bay. In response, the U.S. Fish and Wildlife Service (USFWS) recruited voluntary assistance from four marinas and a high school to conduct precautionary early detection monitoring consisting of vessel hull inspections and adult zebra mussel sampling in 2010. A total of 443 vessel hulls were inspected by marina personnel, and zebra mussels were found on two vessels. A total of 428 sampler nights were completed by high school students. No invasive mussels were found on the samplers, but many snails were collected. The USFWS conducted bottom trawling for new invasive fish consisting of a total of 24 five-minute tows. Trawling was conducted in sites considered to be high risk for introduction of invasive fish. A total of three invasive fish species were captured, all previously detected. *Keywords: Dreissena, Invasive species, Exotic species, Global warming, Experimental design, Zebra mussels.*

DA SILVA, S.E. and SHEAR, H., University of Toronto Mississauga, 3359 Mississauga Rd N., Mississauga, ON, L5L 1C6. **Great Lakes Environmental Indicators and State of the Environment Reporting: Use, Needs, and Limitations.**

Perceptions and use of environmental indicators and state of the environment (SOE) reports by local governments and conservation authority decision makers and practitioner's within the Ontario portion of the Great Lakes and St. Lawrence basin were examined through a web-based survey and follow-up telephone interviews. Indicator and SOE reporting use are described, as well as information needs and limitations and challenges in using indicators and SOE reports to formulate environmental policy at the local level. Information exchange among different levels of governance is also explored. The State of the Great Lakes environmental indicators and SOE reports, developed by the governments of Canada and the United States, were used as a case study.
Keywords: Decision making, Indicators, Great Lakes basin.

DAHL, T.A. and LEWIS, J.W., USACE - Detroit District H&H, 477 Michigan Ave., Detroit, MI, 48226. **The Use of Residual Net Basin Supplies in the Great Lakes.**

The U.S. Army Corps of Engineers' Detroit District provides support to the International Joint Commission for the regulation of Lake Superior and forecasts and monitors levels and flows in the Great Lakes and connecting channels. In order to perform these functions in a timely and cost-efficient manner, the Corps of Engineers and partner agencies in the U.S. and Canada have primarily relied on residual net basin supplies (NBS). This presentation will discuss how residual net basin supplies are calculated and used by the Corps of Engineers' Detroit District. It will also describe some of the advantages and disadvantages of residual net basin supplies relative to supplies based on the sum of individual components of the water balance. *Keywords: Water balance, Forecasting, Water levels.*

DANZ, N.P., Department of Natural Sciences, University of Wisconsin-Superior, Superior, WI, 54880. **Linkages Between Vegetation and Anthropogenic Stress in Tributary Mouth Wetlands of the St. Louis River Estuary.**

The St. Louis River estuary (SLRE) is bounded by natural habitat and highly industrialized areas in the cities of Duluth and Superior. Marshes of the estuary play a critical role in protecting water quality and supporting rare flora and fauna. Our aim here was to evaluate the potential influence of human disturbance on wetland vegetation in the SLRE. Stress was quantified for contributing watersheds with an index that integrated multiple types of human activity. We surveyed 20 wetlands positioned at the mouth of tributaries to the SLRE - vegetation in these wetlands should be subject directly to stresses delivered down the drainage networks of the watersheds. Percent cover of plants in emergent/submergent zones, as well as water quality and substrate information, was recorded in 15 1-m2 quadrats in each wetland. Water depth was a primary control on the distribution of emergent and submergent plants. Anthropogenic stress was also important. Some plant species tolerant of human disturbance, e.g. Coontail, had greater abundance in wetlands with greater stress. Moreover, Coefficient of Conservatism and Floristic Quality Index (FQI) were negatively related to human disturbance. Future work in wetlands of the SLRE will attempt to disentangle the types of stress important to wetland plants. *Keywords: Wetlands, St. Louis River AOC, Urban watersheds.*

DAWSON, F.N., Ontario Ministry of Natural Resources, RR#1, 25th Side Road, Thunder Bay, ON, P7C 4T9. **Monitoring Mammalian Carnivores in the Lake Superior Basin: Challenges & Opportunities.**

Mid-sized carnivores have been proposed within the Lake Superior LaMP Goals & Objectives as a group which should be monitored within the basin. This presentation will briefly discuss species status, and concentrate on the challenges and opportunities in developing such a monitoring program. Twenty species of mammalian carnivores have been reported in the Lake Superior watershed. Five species (gray fox, raccoon, long-

tailed weasel, badger, and bobcat) occur at the northern limit of their distribution in the basin, while one species (wolverine) occurs at the southern limit of its distribution. Others (e.g. least weasel) are reported to be present throughout the watershed however actual records are very limited. Reports of eastern cougar are common however verification of their presence is limited. The remaining species are distributed throughout the basin. Existing carnivore monitoring programs vary from winter track surveys to trapper harvest reports for furbearers and are not uniformly conducted across the basin. Challenges include: a large geographic area; multiple government agencies; a wide range of habitats; specialists vs. generalists; and standardization of protocols. However, opportunities exist with recent non-invasive techniques (remote cameras, genetic sampling) and opportunities to involve the public. *Keywords: Carnivores, Monitoring, Mammals, Cameras.*

DAY, J.[1], STURTEVANT, R.A.[2], SHATTUCK, C.[3], NELSON, D.[3], CASEY, S.[3], KATICH, S.[3], HELD, R.[3], FORSYTH, D.[3], and MOUNTZ, E.[4], [1]NOAA Great Lakes Region, 4840 South State Road, Ann Arbor, MI, 48108; [2]NOAA Great Lakes Sea Grant Network, 4840 South State Road, Ann Arbor, MI, 48108; [3]School of Natural Resources and Environment, University of Michigan, Ann Arbor, MI, 48109; [4]NOAA Office of Ocean and Coastal Resource Management, 1305 East West Highway, Silver Spring, MD, 20910. **Climate Ready Great Lakes.**

The Great Lakes region is predicted to experience significant coastal impacts due to global climate change that are different than impacts being predicted for our ocean coasts. Specialized education, training and community planning will need to be developed to assist Great Lakes coastal communities in adapting to changes resulting from climate change. This project resulted in three educational modules that can be delivered individually or as a unit to prepare local officials to develop climate change adaptation plans for their communities. These outreach modules will be delivered by Sea Grant Program Extension Staff, USDA Extension Staff, Coastal Zone Management Programs, and other trained outreach professionals who work with local community decision makers in the Great Lakes region. Modules were designed to allow for maximum flexibility and adaptability and can easily be modified to include future research and tools that increase the body of information useful for local decision makers. *Keywords: Climate change, Outreach, Planning.*

DEACU, D.[1], FORTIN, V.[1], SPENCE, C.[2], and BLANKEN, P.D.[3], [1]Meteorological Research Division, Environment Canada, 2121 TransCanada Highway, 5th Floor, Dorval, QC, H9P 1J3; [2]Aquatic Ecosystem Impacts Research Division, Environment Canada, 11 Innovation Blvd., Saskatoon, SK, S7N 3H5; [3]Department of Geography, University of Colorado, 260 UCB, Boulder, CO, 80309-0260. **Effect of Improving the Consistency of the Atmospheric Forcing in a Hydrometeorological Model of the Great Lakes Basin.**

Any modification of the land/water surface component of a numerical weather prediction model (NWP) has an effect on the simulated interaction between the atmosphere and the underlying surface. The interaction is missing when the surface component is run in offline mode, as the atmospheric forcing is prescribed. This is the case of most distributed hydrometeorological models. The lack of atmospheric feedback limits our ability to improve such models by altering their parameterizations, and could even be misleading. In this context, we show results from our studies aimed at hindcasting the net basin supply (NBS) to the Great Lakes with a distributed hydrometeorological model (MEC/MESH). Thus, the positive effect on the NBS of a parameterization of the overlake evaporation, modified to better match observed flux data over Lake Superior, was limited by the absence of an atmospheric response producing an amount of overlake precipitation consistent with the simulated evaporation. Since MEC/MESH is based on the surface component of an NWP model (GEM), we ran GEM with the modified surface flux parameterization to generate new atmospheric forcing for the fall and winter months. The new precipitation fields compared better with observations than the original fields, and led to an improved NBS to Lake Superior simulated with MEC/MESH. *Keywords: Atmosphere-lake interaction, Great Lakes basin, Hydrologic budget.*

DEKKER, T.[1], DEPINTO, J.V.[1], RUBERG, S.[2], READ, J.[3], and COLTON, M.C.[2], [1]LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108; [2]Noaa-Glerl, 4840 S. State Rd, Ann Arbor, MI, 48108; [3]Glos, 229 Nickels Arcade, Ann Arbor, MI, 48104. **Designing the Enterprise Architecture of the Great Lakes Observing System.**

The NOAA Great Lakes Environmental Research Laboratory (GLERL) and its partners (Great Lakes Observing System (GLOS), EPA-Great Lakes National Program Office and the United States Geological Survey) are developing a near term design for a comprehensive Great Lakes Observing System. GLERL has charged a team of scientists and engineers led by LimnoTech with the architectural design of this enterprise. A comprehensive observing enterprise begins with an array of data collecting systems, including satellites, aircraft, fixed platforms and buoys, drifters and floats, automated underwater vehicles, towed sensor arrays, and ships. The data collected from these observing systems must then be transmitted to a data management and communications (DMAC) system, which stores and organizes the data for use in developing products and services. Our overall approach for the design of the GLOS enterprise architecture is to begin with the user needs within the Great Lakes and work our way backward through the above progression to ultimately propose an observation and sensing system that will best support those user needs. This presentation will describe the approach taken to design this enterprise through the use of Representative Design Areas of varying scale. We also describe the evaluation of alternatives to achieving our design criteria. *Keywords: Decision making, Observation networks, System design.*

DEPINTO, J.V., REDDER, T.M., RUCINSKI, D.K., and TAO, H., LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108. **Assessing the Impact of Basin Supplies and Regulation on the Upper Great Lakes System with an "Integrated Ecological Response Model" (IERM2).**

The International Upper Great Lakes Study Board is in the final year of a study for the International Joint Commission to evaluate the impacts of Lake Superior regulation plans and basin supply scenarios on the ecosystem and various economic sectors. In support of the decision process, an "Integrated Ecological Response Model" (IERM2) has been developed to evaluate the potential ecological impacts of plausible future basin supply scenarios and regulation. The IERM2 model, which synthesizes the research of scientists comprising the Ecosystems Technical Working Group, quantifies the cause-effect relationship between hydrologic conditions and ecosystem "performance indicators". A suite of more than 30 performance indicators represents a range of coastal ecosystem components, including wetland vegetation, macroinvertebrates, fish, and birds. The IERM2 model includes a suite of visualization tools that allows the user to review summary comparisons for the entire set of indicators and drill down into detailed results for individual indicators. A "Coping Zone" analysis is included to evaluate the potential for significant harm to the nearshore ecosystem to occur as a result of extreme hydrologic conditions. The results of these evaluations are being integrated into a Shared Vision Model to support selection of a regulation plan. *Keywords: Coastal ecosystems, Water level fluctuations, Ecosystem modeling.*

DESOTELLE, D.[1], HAGLEY, C.A.[2], SCHOMBERG, J.[2], O'HALLORAN, S.[3], and REED, J.[4], [1]Desotelle Consulting, Inc., 3031 Branch St., Duluth, MN, 55812; [2]Minnesota Sea Grant, 31 West College Street, Duluth, MN, 55812, [3]University of Wisconsin Extension, PO Box 2000, Superior, WI, 54880, [4]Red Pebble Design, 394 Lake Avenue South, Suite #406, Duluth, MN, 55802, **A View From The Lake: Taking Lake Superior Science From Research to Public Engagement to the Web and to K12 Education.**

Over 2000 people from roughly 150 communities participated in the six years of A View From the Lake 3-hour educational boat trips on western Lake Superior, sponsored jointly by UW Superior Extension and UM Duluth Minnesota Sea Grant. Current research was shared related to topics ranging from impacts of development on water quality, Lake Superior fisheries, climate change, coastal wetlands, and managing for environmental and economic sustainability. Citizen-friendly solutions to environmental and management challenges were provided, resulting in a high rate of adoption of best management practices described on the trips. Funding from Minnesota's Lake Superior Coastal Program is allowing us to increase the impact of the materials we have developed for this program by building an interactive Web site and developing lessons based on program content along with supporting materials for Great Lakes educators. *Keywords: Education, Policy, Lake Superior, Best management practices, Environmental effects.*

DEVANNA, K.M.[1], MAYER, C.M.[1], and SCHLOESSER, D.W.[2], [1]University of Toledo, Department of Environmental Sciences and the Lake Erie Center, Oregon, OH, 43616; [2]USGS Great Lakes Science Center, Ann Arbor, MI, 48105. **Scale-dependent effects of soft-sediment *Dreissena* druses on *Hexagenia* in western Lake Erie.**

An invasive ecosystem engineer, *Dreissena rostriformis bugensis* (quagga mussels), is changing bottom habitat of lakes by covering soft sediment with hard druses. This shift in available habitat type is likely to affect infaunal invertebrates, such as burrowing mayflies (*Hexagenia* spp.). We examined effects of soft-sediment dreissenid druses on mayflies in both small-scale laboratory habitat choice experiments and large-scale spatial analyses. We found that, when given a choice of habitat types: live *Dreissena*, artificial *Dreissena*, or bare sediment, burrowing mayflies select for live dreissenid cluster habitat. At the western basin-wide scale, the presence of *Dreissena* did not inhibit mayfly presence, but there was no spatial cross-correlation between the two taxa. Mayflies at sites without *Dreissena* can achieve high densities, but are highly variable, whereas at sites with *Dreissena*, mayflies are present at a lower mean density, but are less variable. These findings show that at a small spatial scale mayflies prefer *Dreissena*-covered sediment, but at a large-scale are not selecting for or avoiding *Dreissena* druses, suggesting that mechanisms other than *Dreissena* presence determine mayfly distribution in western Lake Erie. *Keywords: Spatial distribution, Dreissena, Hexagenia, Benthos.*

DILA, D.K.[1] and BIDDANDA, B.A.[1], [1]GVSU Annis Water Resources Institute, Muskegon, MI; [2]GVSU Annis Water Resources Institute, Muskegon, MI. **Microbes and Carbon Flux in a Great Lakes Watershed.**

Microorganisms make up the majority of Earth's biological diversity and biomass. They are responsible for cycling roughly half of carbon and oxygen between the atmosphere, hydrosphere and lithosphere. In marine and freshwater environments microbial plankton are the leading primary producers as well as consumers of organic carbon. Although many details of the relationship of microbes to carbon flux remain a mystery, we do know that freshwater ecosystems are highly reactive sites of carbon metabolism and land-margin coastal ecosystems are emerging as key hotspots in the global carbon cycle. Our work examined seasonal changes in carbon flux and microbial community composition along a land to lake gradient in a major West Michigan watershed. From carbon-rich riverine waters to nutrient poor pelagic lake waters, sampling sites included Cedar Creek, Muskegon River, Muskegon Lake and offshore Lake Michigan. Maxima in net primary production occurred in Muskegon Lake (~30-fold higher than Muskegon River and 240-fold higher than Lake Michigan) coincident with maxima in Chlorophyll a concentration and minima in nitrate concentration at this drowned river mouth site. Our findings suggest Muskegon Lake is a highly productive estuary-like transition zone in this Great Lakes watershed. *Keywords: Biogeochemistry, Carbon cycle, Coastal ecosystems.*

DOBIESZ, N.E. and HECKY, R.E., 2205 East 5th St, Large Lakes Observatory, Duluth, MN, 55812. **A web-based tool to aid fisheries management in the Great Lakes.**

Each of the world's great lakes is a large ecosystem managed under multiple jurisdictions. Even with cooperative management agreements, such as the Great Lakes Fishery Commission *Joint Strategic Plan*, fisheries managers are challenged by data management issues that complicate lake-wide analyses and reporting. Data sharing issues arise because of variations in units of measure, data collection procedures, and data storage coding and formats. To address the need for lake-wide data sharing, we are developing database integration techniques and visualization tools with support from the University of Minnesota's Institute on Environment. Our goal is to establish a web-based system of data acquisition, database management, decision support modeling and informative visualization to enable anticipatory management of the world's great lakes. Lake Superior was been selected as the prototype for this project, with techniques and tools in development. We will describe the development and status of a common fisheries management database and the integration of environmental data with fisheries data. A brief demonstration of the tools available at the globalgreatlakes.com web site will include currently available tools and a preview of tools under development.
Keywords: Fisheries, Fish management, Decision making.

DOBSON, T.A.[1], MASSON, C.[2], DOBIESZ, N.E.[3], LAWRENCE, T.J.[4], and VAN DER KNAAP, M.[5], [1]Department of Fisheries and Wildlife, Michigan State University, 13 Natural Resources Bldg., East Lansing, MI, 48824-1222; [2]P.O. Box 10341, Don Mills Stn., Toronto, ON, M4C 0J9; [3]Large Lakes Observatory, University of Minnesota Duluth, 2205 East 5th Street 109 RLB, Duluth, MN, 55812-2401; [4]Great Lakes Fishery Commission, 2100 Commonwealth Blvd. Suite 100, Ann Arbor, MI, 48105; [5]Maxillion Consultancy, P.O. Box 42, 6700AA, Wageningen, Netherlands. **Human Dimensions of Large Lake Resources Management: Research Agenda.**

The human dimensions (HD) of natural resources management describe how and why people value natural resources, and how these influence and impact decision-making. HD informs reconciliation of disparate interests, user negotiations, stakeholder engagement, managerial policy formulation and multidisciplinary research partnerships. Fishery managers make decisions involving finite public resources in which the public, by definition, has a stake. Fisheries also serve as indicators of the ecological health of a society and its ability to prevent or resolve allocation, conservation and regulatory conflicts. This implies a central tension between the natural and social sciences. Large freshwater lakes (over 500km^2) present global management challenges. Conflicts are emerging as expanding, mobile and technologically sophisticated populations compete for scarce and costly ecosystem services and sinks. Common property resources studies integrate multiple, interactional, causal factors. These require examination within nested organizations and at multiple scales. HD studies link anticipatory institutional capabilities with proactive management measures to bring about preferred futures for stakeholders and communities, which are sustainable. Here we report on a proposed human

dimensions of large lakes research agenda. *Keywords: Decision making, Fisheries management, Lake management, Human dimensions, Regional analysis, Large lakes.*

DOKULIL, M.T. and TEUBNER, K., University of Vienna, Department of Limnology, Vienna, A-1090, Austria. **Climate induced variability in the irradiance and temperature dependent spring maximum of phytoplankton in deep alpine lakes.**

Phytoplankton spring dynamics are largely influenced by light dose exposure and water temperature during the initial growth phase. Both physical variables are affected by climate change. Here we analyse the inter-annual variation and timing of total incoming radiation (TIR), temperature, and related variables in two European mesotrophic deep pre-alpine lakes for the period 1982 - 2002. The timing of the phytoplankton spring peak is related to the date when irradiance exceeds 600 Joule cm-2 during winter (timing around JD 15) which acts as stimulating signal for growth. The timing of critical water surface temperature (7 °C at 0m, exceeded first between JD 52 and 103) additionally stimulates algal peak development. As a consequence of climate impact, critical values of temperature related parameters associated with timing of spring phytoplankton shifted forward by 5-10 days per decade. Concurrently the phytoplankton peak occurred 6-7 days earlier per decade. Trends and shifts are significantly related to long distance climate signals such as the North Atlantic Oscillation (NAO) emphasizing the importance of events at the very beginning of the year. *Keywords: Ecosystems, Deep alpine lakes, Climate change, Phytoplankton.*

DOLAN, D.M.[1] and CHAPRA, S.C.[2], [1]University of Wisconsin - Green Bay, Natural and Applied Sciences, Green Bay, WI, 54311; [2]Tufts University, Civil and Environmental Engineering, Medford, MA, 02155. **Updating Great Lakes Total Phosphorus Loadings.**

Through a grant received from the U.S. EPA, Great Lakes National Program Office (GLNPO), an effort has been made to update phosphorus load estimation efforts for all of the Great Lakes with an emphasis on Lakes Superior, Michigan, Huron and Ontario for 1994-2008. Lake Erie phosphorus loads have been kept current with previous funding from EPA and NOAA (ECOFORE). A combination of modeling and data analysis was employed to evaluate whether target loads established by the Great Lakes Water Quality Agreement (GLWQA) have been and are currently being met. Data from federal, state, and provincial agencies were assembled and processed to yield annual estimates for all lakes and sources. A mass balance model was used to check the consistency of loads and to estimate interlake transport. The analysis suggests that the target load has been consistently met for the main bodies of Lakes Superior, Michigan and Huron. However, exceedences still persist for Green and Saginaw Bays. For Lakes Erie and Ontario, loadings are currently estimated to be at or just under the target (with some notable exceptions) Because interannual variability is high the target loads have not been met consistently for the lower Great Lakes. *Keywords: Phosphorus, Mass balance, Water quality.*

DOROBEK, A.C.[1], PETERSEN, S.[1], BADER, J.[1], MACK, J.[2], and KOONCE, J.F.[1], [1]Department of Biology, Case Western Reserve University, Cleveland, OH, 44106; [2]Cleveland Metroparks, 4500 Valley Parkway, Fairview Park, OH, 44126. **Stewardship Liaisons Provide Service Learning Opportunities through Unique Academic and Community Partnerships.**

Great Lakes Innovative Stewardship through Education Network (GLISTEN) aims to provide civic engagement and real-life educational experiences to undergraduates. Undergraduate Stewardship Liaisons are key personnel of the network. The Stewardship Liaison position uniquely links community and academic partners. By embedding Stewardship Liaisons as employees of community organizations, they create collaborations needed to enable application of inquiry-based pedagogy through civic engagement. The joint experience as an employee of a community organization and as an undergraduate liaison for faculty and other students provides the Stewardship Liaison with research and leadership training. The purpose of this paper is to present a test of the effectiveness of the Stewardship Liaison model in the Akron-Cleveland GLISTEN Cluster. Based on experience of Stewardship Liaisons in the cluster and specific experience with implementation of civic engagement in courses at Case Western Reserve University, we found both strengths and weaknesses in pedagogical assumptions and student perceptions of contributions to learning gains. The findings have important implications for training of Stewardship Liaisons and to application of this method in other institutions to increase student engagement and promoting environmental stewardship. *Keywords: Environmental education.*

DOUCETTE, J.S.[1], TRENHAILE, A.S.[2], SHANTZ, M.[3], and VILLARD, P.V.[1], [1]Geomorphic Solutions, 141 Brunel Road, Mississauga, ON, L4Z 1X3; [2]Earth and Environmental Sciences, University of Windsor, Windsor, ON, N9B 3P4; [3]Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Development of a Cohesive Shoreline Recession Model to Determine the Effects of Water Level Fluctuations in the Upper Great Lakes.**

Approximately 12% of the shoreline of the upper Great Lakes is composed of cohesive sediment. Fluctuation of lake levels, whether due to natural variability, climate change or outlet management, could have an impact on the rate of shoreline recession. A model developed by Dr. A. Trenhaile to estimate cohesive shoreline evolution on open ocean shorelines was modified for use in the Great Lakes. The effect of runup impact on the bluff toe was added to the model to account for the narrow or absent beaches on cohesive shorelines in the Great Lakes. The rate of shoreline recession in the model is a result of a dynamic equilibrium between nearshore lowering and runup impact on the bluff toe. An increase in water level leads to an initial period of accelerated recession rate. Conversely, a decrease in water level leads to an initial period of decreased recession. In both cases, the profiles evolve to an equilibrium condition at which the rate of recession is relatively constant. A stand alone executable version of the model was

produced for use by the International Upper Great Lakes Study Coastal Zone Technical Working Group. The stand alone model includes three calibrated sites and is to be used to compare impacts of different water level scenarios on total recession over 109 years. *Keywords: Coastal processes, Water level fluctuations, Sediment transport.*

DOUGLAS, A.G., Climate Change Adaptation at MIRARCO - Laurentian University, 935 Ramsey Lake Road, Sudbury, ON, P3E 2C6. **Development of Water Level Sensitivity Zones for the Recreational Boating Sector.**

Recreational boating is a culturally and economically significant sector within the Great Lakes basin. In 2009, an estimated 19-21 million people participated in a recreational boating activity within the upper Great Lakes states and provinces. Registered boats that occupy Great Lakes waters number from 1.1 to 1.2 million and range in size from small, non-motorized vessels to large power boats and sailboats. It is estimated that recreational boating on the upper Great Lakes generates $3.04B to $3.8B in direct spending which supports 39,500 - 49,500 jobs not including secondary economic benefits. Changes to Great Lakes water levels have a significant impact on recreational boating including boat owners, boating participants and marinas. As part of the International Upper Great Lakes Study, 111 marina owners and operators from around the basin were surveyed in an attempt to quantify losses associated with high and low water levels. These survey results, combined with physical measurement of more than 120 marinas have generated coping or sensitivity zones that estimate economic losses for 3 water level scenarios. With a limited ability to cope with either high or low water levels, this sector could experience significant losses if lake levels increase or decrease significantly. *Keywords: Risks, Recreational boating, Economic evaluation, Coping zones, Water level fluctuations.*

DOVE, A., Environment Canada, Water Quality Monitoring & Surveillance Division, Burlington, ON, L7R 4A6. **Water Quality Status and Trends Update for Lake Superior from the Great Lakes Surveillance Program.**

Environment Canada's Great Lakes Surveillance Program has conducted monitoring on Lake Superior since about 1970, and the data comprise some of the most comprehensive information in existence for such a large lake. A brief overview of the program will be provided, and the long-term trends of major ion and nutrient concentrations will be discussed. An update status for organic contaminant concentrations, including current-use pesticides, will be provided. 2011 is a Cooperative Monitoring and Science intensive field year for Lake Superior; the presentation will end with an update of work being conducted this year. *Keywords: Water quality, Lake Superior, Monitoring.*

DRYER, P.J., U.S. Fish and Wildlife Service, 2800 E. Lakeshore Dr., Ashland, WI, 54806. **Great Lakes Basin Fish Habitat Partnership Development using Lakewide Management Plans.**

The Great Lakes Basin Fish Habitat Partnership was established in 2009 under the National Fish Habitat Action Plan to protect, restore and enhance fish habitat in the Great Lakes and their watersheds. A strategic plan was drafted to establish guiding principles, identify goals and objectives, and select the most critical issues facing fish habitat. Lakewide Management Plans established under the Great Lakes Water Quality Agreement were instrumental in helping the Partnership identify the most critical issues and in setting a direction for fish habitat conservation. The Partnership is conducting a habitat condition assessment to select priority areas for its work. This presentation will highlight how Lakewide Management Plans and the work of the Binational Programs were used in the Partnership's planning and assessments. The Lake Superior Binational Program's Lakewide Management Plan was especially critical for planning because of its ecosystem focus. *Keywords: Habitats, Fish management, Lake Superior.*

DSOUZA, N.A.[1], KAWARASAKI, Y.[2], LEE, R.E.[2], and MCKAY, R.M.[1], [1]Department of Biological Sciences, Bowling Green State University, Bowling Green, OH, 43403, USA; [2]Department of Zoology, Miami University, Oxford, OH, 45056, USA. **Detection of ice nucleating active components in a winter phytoplankton assemblage in Lake Erie.**

Lake wide surveys conducted in the winters of 2007-2010 documented high phytoplankton biomass dominated by a nutrient-replete, low-light adapted, filamentous centric diatom, *Aulacoseira islandica*. Temperatures of crystallization of samples from these blooms showed high ice-nucleating activity (INA) in all samples. The effect of dilution and heat on this activity was assessed, with INA detected at dilutions up to 0.01x and after heat treatments of up to 95°C for 2 h. INA was detected in all size fractions, including samples filtered through a 0.2µm filter suggesting a presence of ice-nucleating macromolecules. A modified SEM approach detailed unusual associations between diatoms as well as non-uniform bacterial colonization on these diatoms. Isolation of bacteria from these assemblages using simple enrichment techniques yielded isolates that exhibited high to moderate INA, suggesting a role for these epiphytic bacteria in this activity. Understanding the ice nucleating activity of the winter phytoplankton in the lake could shed light on the dynamics between the phytoplankton and the extensive ice cover on the lake during winter. This ice nucleating activity, while documented for polar assemblages, has yet not been documented in temperate assemblages, and could play an important role in the ecology of the lake. *Keywords: Ice nucleation, Lake Erie, Diatoms, Ice.*

DUFOUR, M.R.[1], PRITT, J.J.[1], MAYER, C.M.[1], TYSON, J.T.[2], WEIMER, E.J.[2], KOCOVSKY, P.M.[3], and STOW, C.A.[4], [1]6200 Bayshore Dr., Oregon, OH, 43616; [2]305 E. Shoreline Dr., Sandusky, OH, 44870; [3]6100 Columbus Ave., Sandusky, OH, 44870; [4]2205 Commonwealth Blvd., Ann Arbor, MI, 48105. **Estimating larval fish export from the Maumee River: tracking variability through space and time.**

The Maumee River is an important spawning ground for migratory fishes of Lake Erie including; walleye, white bass, gizzard shad and many sucker species. Our goal was to estimate the export of larval fish from the Maumee River to help inform the management of this community and determine the impact of potential local power plant entrainment. Periodic daily larval densities were derived from both ichthyoplankton net and hydroacoustic sampling. Average daily river discharge and power plant intake flows was used to estimate daily export and potential entrainment. Variability at multiple levels (spatial and temporal) influences the sampled densities of larval fish. Preliminary results show species specific distributional patterns in the water column, some being highly aggregated while others more dispersed. Average daily densities varied greatly through time, driven by a few occurrences of very high density. Change across time and space may be related to flow characteristics. To account for variability and add inferential power we will use a Bayesian hierarchical model, which can share information between raw and predicted data, producing a probability distribution of total annual exports. Similar methods applied to estimating entrainment will allow for the quantification of impacts on larval fish communities. *Keywords: Mathematical models, Larval fish, Distribution patterns, Power plants, Tributaries, Bayesian.*

DUNLOP, E.S. and NIENHUIS, S., Aquatic Research and Development Section, Ontario Ministry of Natural Resources,, 2140 East Bank Drive, Peterborough, ON, K9J 7B8.
The ecological footprint of offshore wind power projects in the Great Lakes: effects on fish and a review of potential mitigation measures.

In an effort to reduce greenhouse gas emissions and mitigate impacts of climate change, many nations are promoting the development of renewable energy technologies, including wind power generation, to replace fossil-fuel based energy production. Owing to their strong and constant wind speeds, the Great Lakes are attractive candidates for the future development of offshore wind facilities. Drawing from the literature related to marine wind farms as well as knowledge of Great Lakes ecosystems, we assess potential effects of offshore wind power projects on Great Lakes fish. We find that, despite many parallels, two effects of greater concern in the Great Lakes than in marine environments are the creation of habitat suitable for invasive species at the base of wind turbines and the redistribution of contaminated sediments from dredging. We also find that noise is among the most serious effects to be considered because it can reach sufficient intensity during construction to cause fish mortality and during turbine operation to mask fish communication. Electromagnetic fields emitted by submarine cabling could alter fish distribution in offshore waters where cables connect turbines, but also in nearshore waters where cables carry electricity ashore. We conclude with a review of potential

mitigation measures to curb these impacts. *Keywords: Offshore, Environmental effects, Wind farms, Fish.*

DUNLOP, E.S.[1] and RENNIE, M.D.[2], [1]Aquatic Research and Development Section, Ontario Ministry of Natural Resources, 2140 East Bank Drive, Peterborough, ON, K9J 7B8; [2]Fisheries and Oceans Canada, Experimental Lakes Area, 501 University Crescent, Winnipeg, MB, R3T 2N6. **Changes in depth distribution of lake whitefish coincident with the invasion of dreissenid mussels.**

Great Lakes food webs have changed dramatically since the establishment of dreissenid mussels, highlighted by large declines in *Diporeia* abundance. Recent work has linked lake whitefish growth declines in South Bay, Lake Huron to change in the benthic invertebrate community, where whitefish were distributed more nearshore and diets were dominated by energy-poor nearshore prey following dreissenid invasion. In contrast, recent work from Lake Huron's main basin suggests that lake whitefish have moved deeper. Temporal changes in whitefish depth distributions elsewhere in the Great Lakes have not yet been tested empirically. Here, we use depth-stratified capture data collected from various index netting programs conducted on the Great Lakes to evaluate the extent of depth distributional changes in lake whitefish that are coincident with the invasion of dreissenid mussels. We evaluate trends against isotopic evidence collected in Lake Huron indicating a shift of lake whitefish towards feeding in more inshore habitats. Our work provides an indirect evaluation of the nearshore phosphorous shunt model, which posits that dreissenids have contributed to a shift in productivity from offshore to nearshore areas. *Keywords: Zebra mussels, Biological invasions, Fish.*

EBERHARDT, R.[1], GREENWOOD, S.[2], STADLER-SALT, N.[3], LAPLANTE, E.V.[4], and THOMAS, A.[5], [1]Michigan Department of Natural Resources and Environment, P.O. Box 30473, 530 West Allegan St., Lansing, MI, 48909-7973; [2]Ontario Ministry of Natural Resources, 1235 Queen St. East, Sault Ste. Marie, ON, P6A 2E5; [3]Environment Canada, 867 Lakeshore Rd., Burlington, ON, L7R 4A6; [4]United States Environmental Protection Agency, 77 West Jackson Blvd., Mail Code: G-17J, Chicago, IL, 60604-3507; [5]Batelle, 505 King Ave., Columbus, OH, 43201. **Lake Superior Aquatic Invasive Species Complete Prevention Plan.**

Canada and the United States share responsibility for protecting Lake Superior from the introduction of new aquatic invasive species (AIS). To address this risk, the Lake Superior Binational Program developed the Lake Superior AIS Complete Prevention Plan (Plan), which outlines actions that need to be implemented to close existing vectors and pathways of introduction, including maritime commerce, agency activities, illegal activities, organisms in trade, fishing and aquaculture, canals and diversions, tourism and development, and water recreation. The Plan proposes a comprehensive binational program of education, monitoring and regulation that recognizes the importance of transport, trade and commerce to both the Lake Superior region and the American and Canadian economies. Members of federal, state, provincial

and tribal agencies were involved in the Plan's development, which integrates existing Great Lakes AIS prevention efforts of various agencies into one plan for Lake Superior. The Plan serves as an outline for those with a role in AIS prevention, to develop workplans in support of the Plan. These workplans will reflect institutional and legislative differences between Canada and the United States but will focus on the needs of the Lake and will create domestic decision frameworks necessary to enable actions on the ground. *Keywords: Invasive species, Prevention, Lake Superior, Lake management.*

ECKMAN, K.[1], BRADY, V.J.[2], SCHOMBERG, J.[3], and WERE, V.[4], [1]Water Resources Center, University of Minnesota, St. Paul, MN, 55108, USA; [2]Natural Resources Research Institute, University of Minnesota Duluth, Duluth, MN, 55811, USA; [3]Minnesota Sea Grant, University of Minnesota Duluth, Duluth, MN, 55812, USA; [4]Natural Resources Science and Management, University of Minnesota, St. Paul, MN, 55108, USA. **The Lakeside Stormwater Reduction Project: Evaluating the Impacts of a Paired-Watershed Study on Local Residents.**

Scientists, city utilities staff, and local environmental engineers teamed up with homeowners to determine the best ways to reduce stormwater runoff from the Lakeside residential neighborhood in Duluth. The project investigated various installations and techniques that reduce runoff and can be easily maintained by homeowners. The goal was to identify effective methods to reduce runoff contributing to problems in Amity Creek and the Lester River. Baseline information and residents' views about stormwater issues were obtained from local residents in April 2008 using the knowledge, attitudes, and practices (KAP) study method. The first-round KAP data was used to refine project design, and to identify possible barriers to participation. The study was repeated two years later, and focused on acceptability of the installations to homeowners. This paper presents data and comparative findings from the pre and post project data. The KAP study documented significant and positive improvements in local knowledge, attitudes and practices about stormwater management as a result of the project. The project successfully increased awareness among residents about the impacts of stormwater on Amity Creek and the Lester River, and fostered adoption of stormwater management practices by homeowners. *Keywords: Outreach, Stormwater, Public participation, Social survey.*

EDGAR, R., MORRIS, P.F., PHUNTUMART, V., BULLERJAHN, G.S., and MCKAY, R.M., Biological Sciences, Bowling Green State University, OH, 43402. **Metagenomic analysis of the Mid-winter algal bloom in lake Erie.**

Ice-covered Lake Erie supports a large winter diatom bloom. RNA-seq analysis was used to obtain a snapshot of gene expression in a diatom-enriched sample obtained from a net tow from February 2009. RNA was extracted from the sample and converted to cDNA using reverse transcriptase. cDNA sequencing using 454 technology generated 183,00 reads. Assembly of these sequences using MIRA3 generated 11,577 unigenes with a medium read length of 380bp. BLAST analysis of the unigenes against the NR database revealed that ~60% of the significant hits (E value < 1 E-10) were to diatom genes. In order to estimate the species complexity of the diatom community in this sample, 2384 sequences with homology to the same region on the diatom chloroplast genome were aligned with other known diatom and green algal sequences using MAFFT. The aligned sequences were then subjected to NJ analysis using PAUP. Visualization of the tree shows 7 distinct clusters of sequences suggesting the diatom community contains at least that many species. The largest of these clusters represents the predominance of Aulacoseira in the winter phytoplankton assemblage. *Keywords: Algae, Biodiversity, Lake Erie.*

EDLUND, M.B.[1], JUDE, D.J.[2], and NALEPA, T.F.[3], [1]St. Croix Watershed Research Station, Science Museum of Minnesota, Marine on St. Croix, MN, 55047; [2]School of Natural Resources and Environment, University of Michigan, Ann Arbor, MI, 48109-1115; [3]Great Lakes Environmental Research Laboratory, 2205 Commonwealth Blvd., Ann Arbor, MI, 48108-9719. **Historical Perspectives on the Diporeia Demise: paleolimnological and gut content evidence of food limitation.**

There is correspondence between decline of *Diporeia* and the spread of zebra and quagga mussels in the Great Lakes, but establishing a mechanistic link has been a research challenge. *Diporeia* decline is thought to result from competition for food resources with zebra/quagga mussels, but conflicting evidence suggests food limitation may not be the direct link. To further test this hypothesis, we used paleolimnological analysis of sediment cores from nearshore and offshore southern Lake Michigan to resolve historical relationships between food resources and population dynamics of dreissenid mussels and *Diporeia*. To corroborate paleolimnological analyses, we did gut content analysis using *Diporeia* collected from corresponding stations between the 1980s and 2009. Gut analysis suggest that *Diporeia* fed selectively and diets differ among size classes, stations, and years. Diets show significant shifts during the 2000s, coincident with widespread *Diporeia* declines and rapid expansion of quagga mussels. Sediment cores show changes in diatom communities from 1960-2009 including declines in Aulacoseira and large Stephanodiscus, and increases in small centrics after dreissenid introduction. Community changes in the sediment record are consistent with changes observed in the diet of *Diporeia*. *Keywords: Diporeia, Diatoms, Paleolimnology.*

EICHMILLER, J.J.[1], HICKS, R.E.[2], and SADOWSKY, M.J.[1], [1]1Department of Soil, Water, and Climate, University of Minnesota, 439 Borlaug Hall, 1991 Upper Buford Drive, Saint Paul, MN, 55108; [2]Department of Biology, University of Minnesota Duluth, 207 Swenson Science Building, 1035 Kirby Drive, Duluth, MN, 55812. **Short term frequency and distribution of fecal bacteria sources and virulence genes at Lake Superior beaches.**

Beach closures due to elevated levels of fecal indicator bacteria (FIB) are common in the Duluth-Superior harbor. However, the presence of naturalized populations of FIB and our inability to account for sources of fecal contamination calls into question their use as indicators of health risk. The short-term dynamics of FIB, their sources, and pathogen genes, on three Lake Superior beaches were studied in the summers of 2007 and 2008. Water, sand, and sediment samples were taken twice per week. There was high spatial and temporal variability of FIB and sources of fecal contamination. Waterfowl-borne *E. coli* constituted 5 to 29% of the total *E. coli* population and did not substantially contribute to bacterial exceedances as previously hypothesized. Human fecal contamination was associated with higher densities of fecal indicator bacteria. The site nearest to wastewater treatment plant outfall had the greatest percentage of samples positive for a human-specific *Bacteroides* marker gene (39%). However, the incidence of pathogens was low (1% of total *E. coli*) and precludes the use of indicators to predict their occurrence. Moreover, there was not a significant relationship between the *E. coli* pathogen gene *eae* and traditional and source-specific indicators. *Keywords: Lake Superior, Microbiological studies, Pollution sources.*

ELLISON, R.[1], READ, J.[2], BRIGGS, T.[3], and CARGNELLI, L.[4], [1]USEPA Large Lakes Station/ORD, 9311 Groh Road, Grosse Ile, MI, 48138-1697; [2]440 Church Street, Suite 4044, Ann Arbor, MI, 48109-1031; [3]733 Exeter Road, London, ON, N6E 1L3; [4]Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **"How the HEC did we get here?" And other questions: Governance options for Great Lakes connecting waterways.**

The Lake Huron to Lake Erie Corridor (HEC) is comprised of the St. Clair and Detroit Rivers and Lake St. Clair. Governance of the HEC, like the rest of the Great Lakes connecting waterways - including St. Mary's, Niagara and St. Lawrence Rivers - has always been challenging. How the HEC is defined and functions has consequences for how it is managed. Its waters have been defined as strait, river, lake, nearshore, AOC, and LaMP. What is uniquely challenging about the HEC is that it can function as all of these, simultaneously. Understanding about this system is evolving and so has thinking about how best to manage all of the Great Lakes connecting waterways. The focus on nearshore issues in the Great Lakes Water Quality Agreement renegotiation provides an opportunity to examine governance arrangements in the HEC in regard to current scientific understanding of the function and influence of the HEC on the lakes ecosystem. What would an ideal governance structure look like? The HEC will be used to explore existing governance options - AOC/LaMP, fishery management, Four Party Agreement, HEC Initiative - and provide lessons learned to influence thinking about future governance structures in the rest of the connecting waterways. *Keywords: Governance arrangements, Detroit River, St. Clair River, Management.*

ELMER, H.L.[1], NELSON, D.[2], and STIRRATT, H.[3], [1]Old Woman Creek National Estuarine Research Reserve, Ohio Department of Natural Resources - Division of Wildlife, Huron, OH, 44839; [2]School of Environment and Natural Resources, University of Michigan, Ann Arbor, MI, 48108; [3]National Oceanic and Atmospheric Administration, Coastal Services Center, Chanhassen, MN, 55317. **Great Lakes Climate Needs**

Assessment: A survey of coastal community decision-maker knowledge, skill, interest, and attitudes about climate.

Climate information is critical for effective planning and decision making in the Great Lakes. NOAA, in partnership with EPA and Old Woman Creek National Estuarine Research Reserve, has been funded under the Great Lakes Restoration Initiative to assess the climate needs of Great Lakes coastal community planners, stormwater managers, and natural resource managers. This assessment is designed to increase understanding of Great Lakes community climate change planning needs and to inform development of training and services supporting adaptation decisions throughout the basin. A three tier approach for data collection was implemented to identify and characterize the needs of coastal communities in the Great Lakes region. In-person and telephone interviews, focus groups, and an online survey were implemented across the U.S Great Lakes states. Study results and recommendations will guide development of user-focused services to build community capacity to plan for and respond to climate change, including training and tools to help communities incorporate climate, hazard data and information into new or existing decision-making processes and plans such as Lakewide Management Plans (LaMPs), comprehensive plans, and/or climate adaptation plans. *Keywords: Climate change, Training, Decision making, Planning.*

ENDSLEY, K.A.[1], ERICKSON, T.A.[1], BROOKS, C.N.[1], SHUCHMAN, R.A.[1], SAYERS, M.J.[1], READ, J.[2], and MEADOWS, G.[3], [1]3600 Green Court, Suite 100, Michigan Tech Research Institute, Ann Arbor, MI, 48105; [2]229 Nickels Arcade, Great Lakes Observing System, Ann Arbor, MI, 48104; [3]1085 S. University Avenue, West Hall Rm. 126, U-M Marine Hydrodynamics Laboratories, Ann Arbor, MI, 48109. **The Lake Superior Water Monitoring and Information System: A Web Service with Real-Time Wave Dynamics, Water Quality, and Meteorology Data for Climate and Ecosystem Studies.**

The Lake Superior Water Monitoring and Information System (LSWMIS) offers timely observations of wave conditions, water quality, and weather conditions on Lake Superior from a variety of sources. The Michigan Tech Research Institute with the support of the Great Lakes Observing System and the University of Michigan's Marine Hydrodynamics Laboratory has deployed a buoy at the North Entry of the Keweenaw Waterway. Data from this buoy are transmitted in real-time through a satellite uplink, allowing for their timely distribution on the LSWMIS web service, www.michigantechlakesuperior.org. Near real-time data collected from the Ranger III vessel are also displayed. Software such as the Django web framework, GeoDjango extension and PostgreSQL handle data requests on our Apache servers while Javascript libraries enhance the user's experience with the data by providing sophisticated visualization in charts and maps. The interaction fostered by these free and open-source software has allowed scientists to explore the relationship between surface winds and coastal upwelling. The long-term observations afforded by the instrumentation should help to explain the origin of the recently-verified thermocline. Furthermore, these observations are of great importance to recreational boaters, commercial fishers, and search-and-rescue operations. *Keywords: Waves, Buoy, Observing systems, GLOS, Lake Superior.*

EVANS, M.A.[1], FAHNENSTIEL, G.L.[2], and SCAVIA, D.[3], [1]1School of Natural Resources and Environment, University of Michigan, Ann Arbor, MI, 48109; [2]2Lake Michigan Field Station, Great Lakes Environmental Research Laboratory, NOAA, 1431 Beach St., Muskegon, MI, 49441; [3]4Graham Environmental Sustainability Institute, University of Michigan, Ann Arbor, MI, 48109. **Inadvertent Oligotrophication of North American Great Lakes.**

Ecosystem primary productivity is an important factor in determining both system stability and the provision of ecosystem goods and services. The North American Great Lakes are subjected to multiple stressors and understanding how their primary productivity responds to those stressors is important for understanding system-wide ecological controls. Here we show gradual increases in spring silica concentration (an indicator of decreasing growth of the dominant diatoms) in all basins of Lakes Michigan, Huron, Erie, and Ontario (USA, Canada) between 1983 and 2008. These changes indicate the lakes have undergone gradual oligotrophication coincident with nutrient management. In Lakes Michigan and Huron, slow declines in seasonal drawdown of silica (proxy for seasonal primary production) also occurred early in this time series. However, in recent years, lake-wide silica drawdowns in Lakes Michigan and Huron were punctuated by abrupt drops. The timing of these dramatic production drops appears associated with expansion of populations of invasive dreissenid mussels, particularly quagga mussels, in each basin. The interactive effect of nutrient mitigation and invasive species expansion demonstrates the challenges facing large-scale ecosystems and suggest the need for a new way to look at management regimes for large water bodies. *Keywords: Regional analysis, Dreissena, Diatoms.*

FAHNENSTIEL, G.L.[1], POTHOVEN, S.A.[1], ELLEN, M.E.[2], and SCAVIA, D.[2], [1]Lake Michigan Field Station/GLERL/NOAA, 1431 Beach St, Muskegon, MI, 49441; [2]School of Natural Resources and Environment, Univ. Michigan, Ann Arbor, MI. **Dreissenids and the accidental oligotrophication of Lake Michigan.**

We document recent changes and the current state of the lower food web of southern Lake Michigan after the establishment of large dreissenid populations. Dramatic and significant changes in the lower food web, such as the loss of the spring diatom bloom, large declines in phytoplankton productivity, and a decline of *Mysis* populations, were directly or indirectly attributed to the expansion of *Dreissena rostriformis bugensis*. Total phosphorus concentrations and loadings also have decreased in the last 20 years and secchi disk transparencies have more than doubled in the last 5 years. Changes in the Lake Michigan ecosystem induced by *D. r. bugensis* have produced conditions (e.g., chlorophyll, primary production, transparency, nutrient depletion, etc.) in the offshore pelagic region that are similar to oligotrophic Lake Superior. *Keywords: Invasive species, Water quality, Food chains.*

FAN, Y., FAY, D.M., and CALDWELL, R.J., Great Lakes-St. Lawrence Regulation Office, Environment Canada, 111 Water Street East, Cornwall, ON, K6H 6S2, Canada.
Basin Supplies, Channel Capacities and Lake Superior Regulation Effects.

International Upper Great Lakes Study is a 5 year investigation launched by the International Joint Commission in 2007. One of the key objectives is to review the regulation of Lake Superior outflows and assess the need for improvements to address both the changing conditions of the upper Great Lakes and the evolving needs of the many interests served. The Study is considering effects of the upper Great Lakes basin from Lake Superior downstream through Lake Michigan-Huron to Lake Erie and including the interconnecting channels (the St. Mary's, St. Clair and Detroit River and the Niagara River to Niagara Falls). Physical changes in the St. Clair and Detroit Rivers can have significant impacts on the system. Other factors such as aquatic growth in the river in summer and ice conditions in winter can also affect the water levels and flows. In order to better understand the system and to improve the current regulation plan, several investigations were performed by using Coordinated Great Lakes Regulation and Routing Model (CGLRRM) including: sensitivity analysis of Lake to lake equations and, how the variability of NBS affects the levels of Lake Superior and Lake Michigan-Huron. Through these investigations, some insight is provided into the effects on the system of the Lake Superior regulation plan. *Keywords: Hydrologic budget, Water level fluctuations, Lake Superior.*

FARRELL, J.M.[1], KAPUSCINSKI, K.L.[1], LAPAN, S.R.[2], KLINDT, R.M.[3], CASSELMAN, J.M.[4], and BOWSER, P.R.[5], [1]SUNY College of Environmental Science and Forestry, Syracuse, NY, 13210; [2]NYS Department of Environmental Conservation, Cape Vincent Fisheries Station, Cape Vincent, NY, 13618; [3]NYS Department of Environmental Conservation, Bureau of Fish, Wildlife and Marine Resources, Watertown, NY, 13601; [4]Queen's University, Department of Biology, Kingston, On, K7L 3N6; [5]Cornell University College of Veterinary Medicine, Aquatic Animal Health Program, Ithaca, NY, 14853. **St. Lawrence River Muskellunge Population Trends Following Viral Hemorrhagic Septicemia Virus Outbreak.**

The muskellunge population in the Thousand Islands Region of the St. Lawrence River has been monitored using spring spawning adult surveys and with standardized sampling for young-of-year in nursery areas for over two decades through a cooperative program of the New York State Department of Environmental Conservation and the State University of New York-College of Environmental Science and Forestry. A significant and widespread mortality event of spawning adults began in 2005 and continued over a three-year period. Several of these fish, as well as numerous other fish species, submitted in 2006 and 2007 to the Aquatic Animal Health Program at Cornell University were confirmed to harbor viral hemorrhagic septicemia virus. At the same time round goby, a known reservoir host of the virus, became established in nursery areas and were found in diets of young-of-year muskellunge in 2009. Significant declines in adult captures in

spawning sites and record low young-of-year abundance have followed these events. We use long-term datasets including an angler diary program to infer population and fishery responses and examine changes in prey resources in nursery areas. These data are used to make management recommendations to ensure future population vitality.
Keywords: Fish populations, St. Lawrence River, Management, Muskellunge, Fish diseases.

FETZER, W.W., BROOKING, T.E., JACKSON, J.R., and RUDSTAM, L.G., Cornell Biological Field Station, Cornell University, 900 Shackelton Point Road, Bridgeport, NY, 13030. **Evaluating Relationships Between Water Clarity Changes And Foraging By Yellow Perch And White Perch.**

Changes in environmental conditions can drive shifts in foraging patterns of predators, modifying interactions between predators and their prey. Yellow perch and white perch are common throughout the Great Lakes basin and are known to have wide diet breadth, including fish, zooplankton, and macroinvertebrates. Understanding changes in the diets of these predators following ecosystem change is required to identify the role they play in structuring lake ecosystems. Here, we evaluate yellow perch and white perch diets in Oneida Lake, NY before and after the introduction of *Dreissenid* mussels. Diet samples were collected via a standardized weekly gillnet survey conducted throughout the growing season (June-September) over a 30 year period (1980-2009). Preliminary results suggest yellow perch and white perch are responding to increases in benthic production by foraging more extensively on benthic macroinvertebrates. Additionally, white perch foraging rates on larval yellow perch have increased and are likely contributing to the observed increase in larval yellow perch mortality rates. Results from Oneida Lake can be informative throughout the Great Lakes basin and other locations experiencing changes in water clarity and/or changes in the abundance of these species.
Keywords: Fish diets, Dreissena, Yellow perch.

FINLAY, J.C.[1], SMALL, C.[1], BROVOLD, S.[1], KATSEV, S.[2], STARK, R.[1], and STERNER, R.W.[1], [1]University of Minnesota - TC, 1987 Upper Buford Circle, St. Paul, MN, 55108; [2]Univeristy of Minnesota - Duluth, Large Lakes Observatory, Duluth, MN, 55812. **Controls over Denitrification in Benthic Sediments of Lake Superior.**

Rising levels of nitrate have been observed recently in most of the Laurentian Great Lakes. Increasing nitrate has been well documented in Lake Superior where a recent nitrogen (N) budget suggests that, unlike smaller lakes, little N is buried or denitrified in the sediments. To explore the role of benthic sediments in the lake's N cycle, we used observations of benthic N fluxes and analyses of controls of nitrate removal. Mass balance and sediment flux results suggest that most N deposited to the sediments is recycled to the water column. Denitrification enzyme activity analyses show extremely low rates of denitrification that were not influenced by nitrate, organic carbon and phosphorus availability. Although sediments were oxic through the upper 5cm at most locations, oxygen concentrations were the strongest predictor of variation in

denitrification. Oxygen drawdown in microsites or during transient events appears to create conditions conductive to modest levels of denitrification at sites with relatively high rates of organic matter mineralization. Overall, these results show that sedimentary environments in Lake Superior have little capacity to remove nitrate by denitrification due to low inputs of organic carbon, creating conditions that promote recycling of bioavailable N to the lake's water column. *Keywords: Nutrients, Biogeochemistry, Ecosystems.*

FITZPATRICK, F.A.[1] and FEDORA, M.[2], [1]U.S. Geological Survey, 8505 Research Way, Middleton, WI, 53562; [2]Ottawa National Forest, E6248 US Highway 2, Ironwood, MI, 49938. **Trends in Streamflow for Lake Superior Tributaries during the 20th Century.**

As part of the Lake Superior Binational Program and the Coordinated Science and Monitoring Initiative, an effort is underway to quantify and understand historical trends in streamflow for Lake Superior tributaries. The approach is to examine trends in flow at two gages in the U.S. and two in Canada having at least 50 years of record. Previous regional trend studies have had sparse representation near Lake Superior and the few sites included had different types of trends than tributaries to the lower Great Lakes. Hydrologic characteristics being examined include runoff, peak flows, base flow, and Nature Conservancy's Indicators of Hydrologic Alteration. The watersheds of the tributaries being studied are generally forested with little urban land or water regulation. Streamflow trends will be compared to changes in precipitation, air temperature, and land cover. Preliminary results suggest that since about 1980 snowmelt occurs earlier, from about mid-April to late March, which reflects a climatic signature. Consequently, streams enter base-flow conditions earlier, generally in May instead of June, prolonging summer low-flow conditions. Changes in seasonal, event, and annual characteristics have potential ramifications for habitat, restoration, flooding, erosion, and transport of nutrient, sediment, and contaminants. *Keywords: Tributaries, Lake Superior, Gages.*

FITZPATRICK, M.[1], MUNAWAR, M.[1], and MUNAWAR, I.F.[2], [1]Fisheries & Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [2]Plankton Canada, Burlington, ON. **Assessing the Lake Huron and Georgian Bay lower trophic levels: structure, function and linkages.**

The first lakewide survey of the lower trophic levels of Lake Huron and Georgian Bay was undertaken in the early 1970s and included a comprehensive assessment of the phytoplankton and zooplankton communities as well as primary production experiments. On the whole, the lake was found to be oligotrophic and healthy although some of the nearshore environments (e.g. Saginaw Bay, Severn Sound) were eutrophic and stressed. In the late 1980s, microbial loop (bacteria, picoplankton, nanoflagellates and ciliates) surveys were started to obtain a more holistic picture of the planktonic food web. Beginning in 2002, we implemented a lakewide microbial - planktonic food web survey coupled with a series of nearshore - offshore transect surveys (2004, 2005) in order to understand the dynamics operating in the two habitats. This presentation will examine the structure and function of the microbial - planktonic food web across a variety of nearshore and offshore habitats throughout Lake Huron and Georgian Bay to improve our understanding of the lower and higher trophic level interactions at nearshore and offshore areas. An attempt will be made to investigate the probable reasons for the recent crash of zooplankton and subsequent food web disruptions. *Keywords: Organic carbon, Ecosystem health, Microbiological studies.*

FLORENCE, L.W.[1], LAPORTE, E.A.[1], STEWART, S.R.[2], HAGLEY, C.A.[3], and HART, D.A.[4], [1]Michigan Sea Grant, 440 Church St., Ann Arbor, MI, 48109; [2]Michigan Sea Grant Extension, 21885 Dunham Rd, Suite 12, Clinton Township, MI, 48036; [3]Minnesota Sea Grant, 31 West College St., Duluth, MN, 55812; [4]Wisconsin Sea Grant, 1975 Willow Drive, Madison, WI, 53706. **Teaching with Great Lakes Data: Real Data in the Classroom.**

Teaching with Great Lakes Data is a comprehensive web portal that serves K-12 educators in the Great Lakes region. The website provides educators with resources and tools to help students develop higher-level thinking skills using real Great Lakes data. It includes sociological, physical and biological data sets, lessons, a glossary, and pedagogical tools. Topics for exploration include dead zones, storm surges and seiches, climate, weather, and fish habitat. The website provides a step-by-step explanation of the guided inquiry methodology and includes the tools needed to implement it in a classroom. All lesson materials are aligned to content expectations and education standards and benchmarks. All website materials are available free of charge. *Teaching with Great Lakes Data* is part of a research and education effort supported by the Great Lakes Sea Grant network, Eastern Michigan University, the National Oceanic and Atmospheric Administration (NOAA), the Great Lakes Observing System, the Center for Ocean Sciences Education Excellence-Great Lakes and the NOAA-Great Lakes Environmental Research Laboratory. *Keywords: Education, Great Lakes basin, Observing systems.*

FOGARTY, L.R.[1], BUNNELL, D.B.[2], HAACK, S.K.[1], ROGERS, M.W.[2], and SEELBACH, P.W.[2], [1]US Geological Survey, MI Water Science Center, 6520 Mercantile Way Suite 5, Lansing, MI, 48911; [2]US Geological Survey, Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105. **A Conceptual Model for Lake Michigan Nearshore Ecosystem and Relevance to Lake Michigan LaMP Goals.**

The Lake Michigan Lakewide Management Plan (LaMP) identifies critical concerns that affect beneficial uses of Lake Michigan and provides "Vision, Goals, and Ecosystem Objectives" for lake restoration activities. The U.S. Environmental Protection Agency (EPA) is responsible for the Lake Michigan LaMP and collaborates with federal, state, tribal, and local government and non-government partners to develop and implement the LaMP. To determine whether ongoing monitoring and research efforts were furthering achievement of the LaMP goals, the US Geological Survey (USGS) has begun development of a Lake Michigan ecosystem conceptual framework within which these efforts can be placed. Briefly, the framework considers the key geological, hydrological, and biological processes in each of three main habitats (watershed, nearshore, open lake) and the interaction between these habitats to be important in understanding the nearshore ecosystem. These key processes will be analyzed to determine what data and research has been done and what is needed, or data gaps, to achieve restoration goals. *Keywords: Lake Michigan, Nearshore, Coastal ecosystems.*

FOGARTY, L.R.[1], ISAACS-COSGROVE, N.M.[1], DURIS, J.W.[1], RILEY, S.C.[2], BLEHERT, D.[3], TUCKER, W.C.[4], and PIAZZA, T.M.[4], [1]US Geological Survey, MI Water Science Center, 6520 Mercantile Way Suite 5, Lansing, MI, 48911, US Geological Survey, Great Lakes Science Center; [2]1451 Green Road, Ann Arbor, MI, 48105; [3]US Geological Survey, National Wildlife Health Center, 6006 Schroeder Rd, Madison, WI, 53711; [4]BioSentinel Pharmaceuticals Inc, University Research Park, Madison, WI, 53719. **Botulism Type E Genetic Toxin Potential in Samples Collected in Lake Michigan near Sleeping Bear Dunes National Lakeshore.**

Periodic outbreaks of type E botulism have resulted in die-offs of fish-eating birds in the Great Lakes since at least the 1960s, but outbreaks have become more common and widespread since 1999, particularly in Lakes Michigan and Erie. Extensive bird mortality in northern Lake Michigan near Sleeping Bear Dunes National Lakeshore has caused great public concern, but the mechanisms of toxin exposure for birds remain unknown. In 2010, the U.S. Geological Survey, under the Great Lakes Restoration Initiative, began studying botulism occurrence in the area near Sleeping Bear Dunes National Lakeshore. Botulism is caused by the ingestion of neurotoxins produced by the bacterium Clostridium botulinum and can cause paralysis and death of affected vertebrates. To better understand where type E botulinum neurotoxin (BoNT/E) may be produced in the Lake Michigan environment, sediment, cladophora, dreissenid mussel, and fish samples were collected and analyzed for the presence of the gene responsible for BoNT/E production. Detection and quantification of the BoNT/E gene and direct characterization of BoNT/E activity in samples using a recently developed antibody assay will be discussed. Together, these analyses will provide a basis to better identify food web components, environmental conditions, and/or regions *Keywords: Lake Michigan, Microbiological studies, Avian ecology.*

FOLEY, C.J.[1], ROSWELL, C.R.[1], POTHOVEN, S.A.[2], NALEPA, T.F.[3], and HOOK, T.O.[1], [1]Purdue University Department of Forestry and Natural Resources, 195 Marsteller Rd, West Lafayette, IN, 47907; [2]NOAA-GLERL Lake Michigan Field Station, 1431 Beach St, Muskegon, MI, 49441; [3]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Rd, Ann Arbor, MI, 48108. **Estimating Impacts of Round Goby Predation on Dreissenid Abundance in Saginaw Bay, Lake Huron.**

The establishment and proliferation of dreissenid mussels in the Great Lakes has had many consequences, including shifting nutrients and energy from pelagic and/or offshore zones to benthic, nearshore zones. The presence of dreissenids may have facilitated the subsequent invasion of round gobies (*Neogobius melanostomus*), which are morphologically adapted to take advantage of this food source. Round gobies may be controlling dreissenid abundances through predation but the magnitude of impacts is unclear. We examined round goby abundances, size distributions and gut contents at five sites in Saginaw Bay, Lake Huron. Dreissenids were found ubiquitously in the guts of gobies though dreissenids were not the most abundant food item available at each site. Round gobies as small as 30mm total length had consumed dreissenids. Previous studies suggest that the ontogenetic switch to dreissenids happens later in life, thus smaller gobies may be contributing to increased predation pressure. We combined information concerning biomass estimates, size selectivity indices and energy density estimates in a bioenergetics model. We used this model to estimate overall consumption of dreissenids by round gobies in Saginaw Bay in 2009. Our model could incorporate historic data to estimate past control of dreissenids by round gobies. *Keywords: Dreissena, Lake Huron, Round goby.*

FORTNER, R.W., COSEE Great Lakes, 113 Paula Circle, Oak Island, NC, 28465.
COSEE Great Lakes: Reaching Multiple Audiences for Science and Education.

The Centers for Ocean Sciences Education Excellence (COSEE) include 15 programs in a network supported by the National Science Foundation. The mission of the network is to engage scientists and educators in collaboration to transform ocean sciences education for all. During its five years of programming for scientist-educator interaction in Great Lakes education, COSEE Great Lakes has engaged over 1200 educators and 200 scientists. In addition, student experiences brought nearly 3000 young people into informal education settings for Great Lakes learning, and publications reached thousands in public audiences. For each type of audience, the program used specific recruitment methods, interaction strategies and evaluation techniques. This presentation provides highlights of COSEE programming and outcomes for different audiences and experiences. *Keywords: Education, Outreach, Public education.*

FRY, L.M., URBAN, N.R., MAYER, A.S., and PYPKER, T.G., Michigan Technological University, 1400 Townsend Drive, Houghton, MI, 49931. **Implications of Changes in Climate, Irrigation Intensity, and Population Density for Annual and Seasonal Runoff in the Great Lakes Basin.**

Many ecosystem services in the Great Lakes Basin are dependent on hydrologic flows. Although the Great Lakes Region is generally perceived to be water rich, a disparity between renewable water resources and human water demands has already resulted in water stress in some parts of the region. The water balance model (WBM) (Vorosmarty 1998) is applied to the Great Lakes Basin to investigate the hypotheses that: (1) irrigation intensity and population density currently cause water shortages; (2) these shortages will be exacerbated by climate change; and (3) the geographic distribution of shortages is not uniform within the Great Lakes basin. To investigate these hypotheses, the WBM model, which quantifies water budget components at a 0.5 degree spatial resolution, is driven by scenarios of changes in irrigation intensity, climate, and population density to quantify impacts of these factors on seasonal and annual runoff. The model is also used to evaluate the relative importance of changes in temperature (small prediction uncertainty) and rainfall (large prediction uncertainty) in causing water stress. This work is conducted as a screening tool to identify locations for more focused research into the impacts of these drivers on ecosystem services provided by water resources of the Great Lakes Region. *Keywords: Hydrologic budget, Climate change.*

FUJISAKI, A., WANG, J., HU, H., and SCHWAB, D.J., NOAA/Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48108, USA.
Comparison of ice-ocean models for Lake Erie.

Ice cover is an inevitable physical process in Lake Erie that might significantly affect the regional weather and climate, its circulation, and ecosystem. High-resolution coupled ice-ocean models are useful to assess such impacts. Especially, for the future long-term simulations, a parallelized ice-ocean model is preferable. In this study, a parallelized ice-ocean model is configured for Lake Erie with horizontal 2km grids and vertical 21 layers through 1 April 2003 - 31 December 2004, as a similar configuration to the Great Lakes Ice-circulation Model (GLIM, Wang et al. 2010). The ocean part is based on Princeton Ocean Model. The ice model employs the Elastic-Viscous-Plastic rheology and the 0-layer ice thermodynamics. The ice-ocean model reasonably reproduces the seasonal variation of ice area compared with satellite-derived observation. The model results are discussed in comparison with the updated result of GLIM. Impacts of shortwave radiation on water surface temperature and ice extent are also discussed based on the model results with well-known Zillman (1972) and Cotton (1979) whose coefficients are regression estimates for Lake Erie. *Keywords: Ice, Lake Erie, Model studies.*

FUSARO, A.[1], STURTEVANT, R.A.[1], RUTHERFORD, E.S.[1], BAKER, E.[2], and LARSON, J.[2], [1]NOAA Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108; [2]School of Natural Resources and Environment, University of Michigan, Ann Arbor, MI, 48108. **GLRI Enhancements to the Great Lakes Aquatic Nonindigenous Species Information System.**

The Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS - http://www.glerl.noaa.gov/res/Programs/ncrais/glansis.html) is a Great Lakes specific node of the USGS Nonindigenous Aquatic Species (NAS) system. GLANSIS has been selected as the backbone for AIS information reporting for the Great Lakes region under the Great Lakes Restoration Initiative. Significant enhancements to GLANSIS have been achieved in the last year and more are forthcoming. These include listing and addition of information for range expansion and high risk species (potential future invaders), revision of impact data to better support risk assessment, incorporation of enhanced bibliographic information, and inclusion of a new field for management information. Funding for this

project was received via President Obama's Great Lakes Restoration Initiative. For more information on the Initiative and Action Plan go to www.greatlakesrestoration.us
Keywords: Invasive species, Management, Outreach.

GANNON, J.E., International Joint Commission (retired), 9211 Huron River Dr., Dexter, MI, 48130. **Invasive Species plus Climate Change: The Perfect Storm for Lake Superior.**

The effects of invasive species and climate change likely will combine as a "perfect storm" to adversely affect ecosystem quality and stability in Lake Superior. The invasive percid, the ruffe, is a case in point. Introduced via the ballast vector into St. Louis Harbor in the mid-1980's, it has remained confined to warmer river mouths and embayments in western Lake Superior, likely inhibited by the cold waters of the lake for more rapid temporal and spatial spread throughout the lake and downstream. Warming of the lake by climate change will increase the likelihood of the spread of the ruffe and the susceptibility of the lake to other warm and cool-water species invasions. Furthermore, the unique coldwater community in the lake could be jeopardized. Overall, I consider the quality and quantity of ecological and technological invasive species on Lake Superior and the other Great Lakes to be meritorious. What is insufficient is the translation of research findings into public understanding and outcry for action. Such public support is essential to garnering the political will for necessary policy changes to close the "open door" to invasive species introductions from ballast water and other pathways. In addition, the current negotiations on revising the Great Lakes Water Quality Agreement need to include invasive species. *Keywords: Climate change, Invasive species, Lake Superior.*

GERACE, A.D. and SCHOTT, J.R., 54 Lomb Memorial Drive, Rochester, NY, 14623.
Demonstrating Landsat's New Potential to Monitor Case 2 Waters.

The Landsat program has been in operation since 1972 and represents the longest running, continuous archive of modest resolution satellite imagery of our Earth's surface. The Operational Land Imager (OLI) is a new sensor being developed by the joint USGS-NASA Landsat Data Continuity Mission that exhibits an exciting potential to be useful for monitoring case 2 waters. With upgrades such as a Coastal Aerosol band, 12 bit quantization, and improved signal-to-noise, previous studies indicate that OLI should be radiometrically superior to its predecessors, enabling it to be used for water studies. Through the use of simulated data we showed that OLI can retrieve the levels of 3 main water quality indicators to within 7% when atmospheric effects are ignored. Since the atmosphere represents a major source of error when measuring water quality from space, significant efforts are being made to accurately remove its effects from simulated data. OLI will not be equipped with the bands required by traditional water-based atmospheric correction algorithms so this work presents a new technique that was developed specifically for the OLI instrument. Preliminary studies indicate that when atmospheric effects are included, OLI can retrieve the levels of the 3 water quality parameters to within 15%, which is within the desired error range. *Keywords: Water quality, Landsat, Remote sensing, Atmospheric correction, Monitoring, Case 2 waters.*

GERLOFSMA, J. and BAILEY, S.A., Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Assessment of plankton density in ballast water samples using a High Resolution Laser Optical Plankton Counter and FlowCAM.**

Fisheries and Oceans Canada, in partnership with Transport Canada, has purchased a high resolution Laser Optical Plankton Counter (HR-LOPC) and a FlowCAM with the aim to develop reliable and accurate protocols for ballast water inspection. The HR-LOPC has the capability of acquiring rapid counts of the number of particles in a large volume sample. The FlowCAM, an imaging flow cytometer, can generate quality images of particles in a small volume sample, allowing the user to assess the composition of particles in a sample. It is envisioned that these two tools could be used in combination to rapidly enumerate the density of particles in a ballast water sample, ensuring that they are in compliance with Canada's Ballast Water Control and Management Regulations. Here, we will present data from laboratory tests evaluating the accuracy, precision and reliability of these tools for enumeration of plankton greater than 50 um (minimum dimension) in preserved samples. We will discuss the strengths and weaknesses of the tools for use in ballast water compliance testing based on data collected thus far. *Keywords: Zooplankton, Ballast water.*

GERTZEN, E.L. and DOKA, S.E., Great Lakes Laboratory for Fisheries & Aquatic Sciences; Fisheries & Oceans Canada, 867 Lakeshore Road, box 5050, Burlington, ON, L7R 4A6. **Assessment of Fish Habitat Supply in Long Point Bay, Lake Erie in Response to Water Level Regime.**

The International Upper Great Lakes Study is evaluating the effects of alternative Lake Superior water level regulation plans on the ecological communities of the Upper Great Lakes. We assessed the habitat supply for fish communities in Long Point Bay, Lake Erie under different water level scenarios. While Lake Erie water levels are not affected significantly by upstream regulation, the water level regime is expected to undergo significant alteration due to climate change. Long Point Bay is an important area that provides habitat to many fish species, including several species at risk. Species were grouped by life stage into guilds based on vegetation and temperature preferences. Weighted suitable habitat area was described using a guild based habitat model, which depends on the interaction of habitat characteristics of emergent and submergent vegetation, fetch, substrate composition, temperature and water depth. Our objective was to develop a functional response of weighted suitable area across a range of water level scenarios (increases and decreases in the mean and variance of water levels). Results suggest that habitat supply is affected by both water level and fluctuations, especially as interacting factors, including emergent and submergent vegetation, depth and wet area, change substantially across water level regimes. *Keywords: Water level fluctuations, Habitats, Fish populations.*

GEWURTZ, S.B. and MCGOLDRICK, D.J., Water Science & Technology Directorate, Environment Canada, Burlington, ON, L7R 4A6. **Evaluating Environment Canada's Fish Contaminant Monitoring and Surveillance Program through power analysis: Optimizing effort to meet future requirements.**

The Fish Contaminants Monitoring and Surveillance Program (FCMSP) has been measuring the concentrations of contaminants of concern in top predator fish collected from the Great Lakes since 1977. Until recently, the focus of monitoring has been on legacy contaminants such as PCBs and mercury. As new classes of contaminants emerge, so do requirements to generate new data. With limited resources, power analysis is useful for determining optimal within- and between-year sample sizes for a given contaminant within monitoring programs. Using the FCMSP dataset of total-PCB from Lake Ontario as an example, we estimated the power to detect a 5% annual decrease in concentration over a range of within- and between- year sample sizes. Statistical power increased with both within-year replication and length of the program. However, the increase in power leveled off for within-year sample sizes of approximately 10-15, suggesting that replication greater than 15 would not be worth the additional effort and analytical costs. In general, a statistical power of greater than 80% is desirable and in the PCB dataset this level of power was only approached following 10 years of data collection. The same approach was applied to both legacy and emerging contaminants of concern to evaluate and optimize the future monitoring efforts of the FCMSP *Keywords: Biomonitoring, Contaminants, Fish.*

GINN, B.K. and DENNIS, M., Lake Simcoe Region Conservation Authority, 120 Bayview Parkway, Newmarket, ON, L3Y 4X1. **Distribution and seasonal variation of sediment phosphorus in Lake Simcoe and the Holland River (Ontario, Canada) and factors leading to anoxic release.**

Lake Simcoe has been the focus of many environmental studies due to concerns of increased nutrient loadings and declines in coldwater fish habitat. One topic, which has not been studied in detail, and a component missing in current water quality models, is the concentration of bio-available phosphorus bound in sediments and the potential for release (i.e. internal loading) under anoxic conditions. In this study we measured sediment phosphorus in Lake Simcoe and the Holland River both spatially (20 lake and six river stations) and temporally (February to November, 2009 - 2011) in order to assess (1) current phosphorus concentrations in the lake, as well as differences between areas; and (2) seasonal changes in these concentrations. Using a GIS-based kriging approach, we constructed a map of sediment phosphorus with statistically validated interpolations to identify areas of high concentration for further study. From this study, we have found significant reservoirs of sediment-bound phosphorus in both Lake Simcoe and Holland River (up to 1400 ug/g), environmental conditions which lead to internal loading, and suggest a possible method of nutrient transport across the lake. *Keywords: Sediments, Phosphorus, Lake Simcoe.*

GOETTEL, R.G., Illinois-Indiana Sea Grant Program, University of Illinois, 290 NSRC, MC-635, 1101 W. Peabody Dr., Urbana, IL, 61801. **Extending Learning beyond the University Classroom and into the Community: A Model for Civic Action to Prevent AIS Spread.**

A University of Illinois Natural Resources and Environmental Sciences service-learning course engages students in relevant and meaningful service to local youth in area schools and to the community at-large. In addition to enhancing academic understanding about aquatic invasive species and biodiversity concepts, students learn how to identify community assets; how to affect change; and how to develop leadership and communication capacities to inspire environmental action in others to help prevent spread of aquatic invaders. This presentation will offer concrete examples of what made this course valuable to 61 university students, who have participated in the past 3 years, in terms of their learning outcomes,as well as the benefits to partnering school teachers and students and community organizations who helped disseminate important messages to the public to address this issue. The presenter will share examples of these community stewardship projects and encourage a dialogue with attendees about this service-learning experience. *Keywords: Community partnerships, Ecosystem health, Undergraduate education, Invasive species, Service-learning, Education.*

GOETTEL, R.G. and HALLESY, T.E., Univ. of Illinois, 390 NSRC, MC-635, 1101 W. Peabody Dr., Urbana, IL, 61801. **Creating New Understandings of Great Lakes and Marine Issues through "Fresh and Salt" Curriculum.**

Our Great Lakes and oceans are valuable assets that must be protected. To preserve aquatic environments, an informed public is essential. As future environmental stewards and decision makers, students must develop awareness and understanding of Great Lakes and marine issues to preserve these dynamic systems. This poster describes the methodologies employed to integrate ocean and Great Lakes activities into existing science curriculum. The COSEE Great Lakes Fresh and Salt curriculum incorporates 14 multidisciplinary lessons that foster enhanced science process skills including inquiry, critical thinking, and synthesis. Designed to be used by educators in grades 5-10, this exemplary collection encourages integration of Great Lakes and Ocean Literacy Principles into educator's instruction. Use of this curriculum resource will expose students to engaging activities, fostering new understandings about marine and freshwater concepts. This curriculum collection provides educators and students with insights into the vital contributions of important Great Lakes and ocean science issues. *Keywords: Environmental effects, Science process skills, Great Lakes basin, Marine education, Environmental education, Great Lakes and marine literacy.*

GOETTEL, R.G.[1], MARTZ, M.A.[2], HALLESY, T.E.[1], MCCARTNEY, A.[2], and KAMMIN, L.A.[1], [1]IL-IN Sea Grant Program, University of Illinois, 390 NSRC, MC-635, 1101 W. Peabody Dr., Urbana, IL, 61801; [2]Pennsylvania Sea Grant, Tom Ridge Environ. Center, 301 Peninsula Dr., Suite 3, Erie, PA, 16505. **Undoing the Great Lakes Chemical Brew: Education and Outreach Tools for Effective Decisions Regarding Safe Disposal of Unwanted Medicines.**

Traces of chemicals from pharmaceutical and personal care products (PPCPs) have been found in many streams tested in the United States. Impacts from improper medicine disposal or storage of these chemicals range from harm to fish and other aquatic wildlife, to negative impacts on human health from drug misuse due to improperly stored medicines.A new project funded by the Great Lakes Restoration Initiative is providing the public with training and tools necessary to help them understand impacts of improper PPCP disposal, as well as actions they can take to mitigate the harmful effects and improve Great Lakes ecosystem health. This presentation will offer a sampling of the outreach tools and education resources that have been developed by Sea Grant Programs in Illinois-Indiana, Pennsylvania, New York, and Ohio, and will demonstrate how they are being used in five Great Lakes states. Target audiences include teachers and students, non-formal educators, 4-H leaders and members, and anglers. In addition, we will share information on project goals and target milestones regarding the quantity of pills to be collected and disposed of properly, number of new collection programs in Great Lakes states, and the newly formed networks of students and anglers, who will be working to slow the flow of these chemicals into the GL watershed. *Keywords: Environmental contaminants, Pharmaceuticals, Public education, Safe disposal techniques, Environmental education.*

GOGINENI, P., JANUSKA, B., MINNIEFIELD, C., and SIMOLIUNAS, S., Detroit River Remedial Action Council, 665 W. Warren Avenue, Detroit, MI, 48201, USA. **The Tale of Two Cities and Two Judges.**

In 1977, Judge John Feikens took over the Detroit wastewater treatment plant giving it to the politicians to fix all problems. Today, the plant has an antiquated incineration system burning sludge, uses elemental chlorine for disinfection, and has no tertiary treatment. It is also involved in massive corruption cases. In 1984, Judge Paul G. Garrity took over the Boston wastewater treatment plant and gave it to the US Army Corps of Engineers to remedy. The result is the second largest US wastewater treatment plant on Deer Island in Boston Harbor. It uses anaerobic digestors to produce methane and fertilizer. Boston Harbor was cleaned up and the plant meets all environmental requirements. Detroit has spent more money on their old plant than Boston has in building a new plant. Technology is a better answer than political initiative.
Keywords: Pollution load, Control systems, Environmental policy.

GOLDSBOROUGH, L.G.[1], WRUBLESKI, D.A.[2], and BALL, G.[3], [1]Department of Biological Sciences, University of Manitoba, Winnipeg, MB, R3T 2N2; [2]Ducks Unlimited Canada, Stonewall, MB; [3]Manitoba Conservation, Winnipeg, MB. **Carp and Culverts: Preparing to Restore Delta Marsh, One of the Largest Coastal Wetlands in North America.**

Delta Marsh, on the south shore of Lake Manitoba in central Manitoba, has become highly turbid over the past four decades. There has also been a near-total loss of submersed macrophytes and emergent plant islands from marsh bays, deteriorating water quality and more frequent phytoplankton blooms, and encroachment of hybrid cattails (*Typha* X *glauca*) into shallow inshore areas. These change are due, we believe, to the stabilization of lake water levels in 1961, increases in nutrient loading from the surrounding landscape, and invasion by Common Carp. A multi-stakeholder restoration project is underway, with the first step, exclusion of large Common Carp, anticipated to begin in 2012. For the past two years (2009-2010), we have been monitoring size demographics of fish populations in Delta Marsh which show there has been a marked increase in the mean size of the Common Carp population since the 1990s, with few small individuals indicative of a population recruitment failure. We are also monitoring water quality (turbidity, chemistry) and submersed macrophyte distribution as a baseline for evaluating the relative success of Common Carp exclusion at increasing water clarity and permitting reestablishment of marsh vegetation. *Keywords: Coastal wetlands, Restoration, Carp, Water level fluctuations.*

GORMAN, O.T.[1], YULE, D.L.[1], and STOCKWELL, J.D.[2], [1]U.S. Geological Survey, 2800 Lake Shore Drive East, Ashland, WI, 54806; [2]Gulf of Maine Research Institute, 350 Commercial Street, Portland, ME, 04101. **Diel Migration and Habitat Coupling in the Lake Superior Fish Community: Consequences for Ecosystem Health and Function.**

Diel patterns of distribution of fishes in nearshore (15-80 m depth) and offshore (>80 m) waters of Apostle Islands region of Lake Superior were described using bottom trawls, mid-water trawls and hydroacoustic gear during day and night sampling along a series of transects targeting depths of 15-30 m, 30-60m, 60-90m, and 90-120 m. Resulting distribution data revealed three types of diel migration: diel vertical migration (DVM), diel bank migration (DBM), and no diel migration. Applying our results to biomass estimates for Lake Superior revealed that DVM accounts for 57%, DMB 40%, and non-migration 3% of the total biomass in nearshore waters. In offshore waters DVM accounts for 67%, DMB 10%, and non-migration 23% of the total biomass. The high degree of diel migration by fish in Lake Superior effectively links shallow and deepwater habitats, and benthic-demersal and pelagic habitats, and thus facilitates energy transfer within the lake ecosystem. Other Great Lakes with diminished DVM due to loss of native ciscoes and reduced abundance of exotic pelagic fishes (rainbow smelt, alewife) in combination with benthification due to expansion of exotic dreissenid mussels may have reduced potential for energy transfer and secondary production of fish biomass compared to Lake Superior. *Keywords: Ecosystems, Migrations, Fish.*

GORMAN, O.T.[1] and HRABIK, T.R.[2], [1]U.S. Geological Survey, 2800 Lake Shore Drive East, Ashland, WI, 54806; [2]University of Minnesota - Duluth, 207 Swenson Science Building, Duluth, MN, 53706. **Fish Communities of Nearshore and Offshore Waters of Lake Superior: Patterns, Connections, and Trends.**

More than half of Lake Superior is >160 m deep but the focus of most research on the fish community has been in the nearshore waters, where the depth is < 81 m. The fish community in nearshore waters is dominated by lake cisco, bloater, lake whitefish, rainbow smelt, and lean lake trout while in offshore waters, kiyi, deepwater sculpin, and siscowet lake trout dominate. Examination of species distributions across depths ranging from 20 to >300 m revealed three species assemblages. The aforementioned nearshore and offshore fish communities occurred in the <81 m depth zone and at depths >160 m, respectively. The intermediate 81-160 m depth zone contained a mix of species from nearshore and offshore zones. Size and age of some species increased with depth so that juvenile and adult life stages occupied different depth zones. Other species showed concurrent distributions of juveniles and adults. Since 2001 community biomass has declined in nearshore waters, but has remained stable or increased in offshore waters. Diel, seasonal and ontogenetic movements of fish across habitats appear to facilitate connectivity and energy transfers between shallow and deep water zones.
Keywords: Lake management, Ecosystems, Fish populations.

GOTO, D.[1], RUCINSKI, D.K.[2], DEPINTO, J.V.[2], LUDSIN, S.A.[3], SCAVIA, D.[4], and HOOK, T.O.[1], [1]Forestry and Natural Resources, Purdue University, 195 Marstellar, West Lafayette, IN, 47907; [2]LimnoTech Inc., 501 Avis Drive, Ann Arbor, MI, 48108; [3]Evolution, Ecology, and Organismal Biology, The Ohio State University, 1314 Kinnear Road, Columbus, OH, 43212; [4]Graham Environmental Sustainability Institute, University of Michigan, 625 E Liberty St, Ann Arbor, MI, 48104. **Elucidating Indirect Impacts of Seasonal Hypoxia Development on Fish Populations in Lake Erie Using a Spatially Explicit Individual-Based Model.**

Hypoxia can induce a variety of ecological and physiological responses in fish. A mechanistic understanding of how hypoxia affects fish at the population level is, however, often elusive. In Lake Erie, hypolimnetic hypoxia develops in late summer, which severely limits access to prey resources for demersal fish species and may have cascading effects on pelagic species. In this study, we developed a spatially explicit individual-based bioenergetics model to understand how hypolimnetic hypoxia influences population and predator-prey dynamics of walleye, yellow perch, emerald shiner, rainbow smelt, and round goby in Lake Erie. The fish bioenergetics models were then linked with a hydrodynamics-water quality model that was calibrated with 2005 field data. By using the linked models, we assessed changes in growth, survival, and movement of these fishes by tracking individuals' state variables at sub-daily time steps during summer. Preliminary simulation indicated that during the peak hypoxia month, fishes mostly remained above the thermocline. Resulting changes in thermal experiences and increased interactions among fishes influenced their growth and survival. Simulation

results demonstrate that sublethal effects of hypoxia can have indirect ecological consequences on overall fish population dynamics in Lake Erie. *Keywords: Individual-based model, Lake Erie, Hypoxia, Fisheries, Mathematical models.*

GRABAS, G.P. and ROKITNICKI-WOJCIK, D.B., Environment Canada - Canadian Wildlife Service, 4905 Dufferin St, Toronto, ON, M3H 5T4. **The condition of coastal wetlands in the Lower Great Lakes: Coastal Habitat Assessment and Monitoring Project 2009-2010.**

Over the last century, Great Lakes coastal wetlands have disappeared at an alarming rate. Government, agencies, local groups, and individual citizens have identified the need for conservation and monitoring of these important ecosystems. Environment Canada's Coastal Habitat Assessment and Monitoring Project (CHAMP) was initiated in 2009 to determine coastal wetland condition of sentinel sites in lakes Ontario, Erie, and Huron-Erie corridor. For geophysical condition, water quality was determined and for biotic condition breeding bird community, aquatic macroinvertebrate community, and submerged aquatic vegetation community were surveyed. Using a suite of indices we found that the condition of 12 Lake Ontario sites sampled in 2009 can be separated longitudinally into two groups. In Lake Ontario, western sites have poorer water quality and biotic communities than eastern sites. This is likely a result of greater levels of urbanization in the west. In 2010, 12 Lake Erie sites were sampled. We found that Long Point sites have better water quality and biotic communities than the other Lake Erie sites. We attribute these differences to low levels of human disturbance at Long Point. Here we illustrate the importance of basin level monitoring to identify conservation priorities and determine basin-level trends in wetland condition. *Keywords: Coastal wetlands, Assessments, Bioindicators.*

GRANADOS, M.[1], MANDRAK, N.E.[2], and JACKSON, D.A.[3], [1]McGill Univeristy, 1205 Docteur Penfield, Montreal, QC, H3A 1B1; [2]Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [3]University of Toronto, 25 Willcocks Street, Toronto, ON, M5S 3B2. **Synthesizing reference conditions for highly disturbed sites though best professional judgment.**

Reference sites, subjected to minimal disturbance, provide a set of species to contrast against test site data. However, what if disturbance is ubiquitous? What if comparable reference sites are absent? Development and industrialization has rendered the Detroit and St. Clair rivers devoid of reference sites. In this paper, a novel application of best professional judgment was developed to generate a set of species characteristic of a reference condition site. Members of the Huron-Erie Corridor Steering Committee, comprised of partners that manage the corridor, were surveyed to produce a hypothetical data matrix of the fishes present in the rivers in the absence of anthropogenic disturbance. The data matrix was subsequently integrated into a Principal Coordinates Analysis with test site fish community data to determine the direction of community change across sampling periods. The results indicate change towards the reference condition, however

the reference condition also demonstrated the loss of species over time. The application of the best professional judgment approach towards reference conditions provides a novel and versatile method to interpret community change; and allows users to define the species matrix, thus affording practitioners the ability to select specific assemblages coincident with restoration objectives. *Keywords: Assessments, Reference condition, Detroit River, Best professional judgment, St. Clair River.*

GREB, S.R.[1], GARRISON, P.J.[1], and OWENS, D.W.[2], [1]Wisconsin Depart. Natural Resources, 2801 Progress rd., Madison, WI, 53716; [2]US Geological Survey, 8505 Research Way, Middleton, WI, 53562. **Continuous in-situ monitoring of the nearshore area off Kewaunee, WI.**

The nearshore region of the Great Lakes is a dynamic transition zone between the terrestrial and open water environments. These nearshore areas can play a significant role in ecosystem processes and functions that influence the larger open-water ecosystem. A number of natural processes as well as anthropogenic influences collectively impact the nearshore area. In addition, invasive species, such as the prolific dreissenid mussels profoundly affect the mechanism, rates and transport of nutrients. The goal of this continuous monitoring station is to better understand the interactions and dynamic nature of the physical, hydrological, biological and chemical components of the nearshore zone. The value in establishing a continuous monitoring site is the ability to collect simultaneous data on multiple parameters and be able to examine interrelationships between these physical, biological and chemical measurements. Monitoring stations can be used to answer both science questions and provide public information. Science questions this station will help address include: What is the nearshore zone response to episodic events? What are the long-term trends of nearshore water quality? How does Cladophora biomass respond to environmental conditions? This paper discusses some of the preliminary finding from 2010 and our future plans *Keywords: Cladophora, Continuous monitoring, Lake Michigan, Water quality.*

GREEN, P.A.[1] and SMITH, S.S.[2], [1]National Park Service, Houghton, MI, 49931; [2]USGS Western Fisheries Research Center, Seattle, WA, 98115. **Developments in Emergency Ballast Treatment Technologies.**

USGS scientists have developed advanced mixing methodologies for ballast water that enable the development of ballast treatment systems that can be mounted on skids and lifted onto the ship for emergency or interim treatment. In this paper the authors summarize progress to date on ballast research and discuss how a skid mounted system could be deployed within the Great lakes basin to treat ballast. The authors are working with a research team to evaluate cost effective options for salt water and freshwater vessel needs. *Keywords: Ballast, Invasive species.*

GREEN, S.A.[1], SHUCHMAN, R.A.[2], KERFOOT, W.C.[3], BROOKS, C.N.[2], SAYERS, M.J.[2], ENDSLEY, K.A.[2], and JESSEE, N.L.[2], [1]1400 Townsend Drive, Department of Chemistry, Houghton, MI, 49931; [2]3600 Green Court, Suite 100, Michigan Tech Research Institute, Ann Arbor, MI, 48105; [3]1400 Townsend Drive, Department of Biological Sciences, Houghton, MI, 49931. **Supporting GLOS through taking remote sensing algorithms operational and increasing access to sensor data.**

Michigan Tech University is supporting the extension of GLOS capabilities through several remote sensing, buoy, sensor network, and website outreach efforts. Daily estimations of chlorophyll-A, dissolved organic carbon, and suspended minerals through an MTRI-derived satellite imagery algorithm will be available for cloud-free days. Areas of Concern are also being assessed. Estimations of primary productivity and harmful algal blooms through advancement algorithm enhancement are under development. A new nearshore buoy was deployed north of the Keweenaw Waterway during the summer of 2010 and will return in 2011 along with a second buoy at the south entrance of the Keweenaw Waterway in collaboration with GLOS, the National Park Service, and the U-M Marine Hydrodynamics Laboratories. Data collected included wind, wave, and thermistor data up to 19m deep. 2011 will add water quality data. The Ranger III Park Service vessel that travels to Isle Royale was instrumented with water quality and meteorological sensors. Thermistor chains were deployed in the Keweenaw's Portage Canal with temperature data collected at 1-6m in depth. All data are available through www.michigantechlakesuperior.org as well as GLOS, and buoy data are also accessible through U-M MHL and the National Data Buoy Center. *Keywords: Observing systems, Buoys, Remote sensing.*

GRONEWOLD, A.D. and HUNTER, T., Great Lakes Environmental Research Laboratory, National Oceanic and Atmospheric Administration, Ann Arbor, MI. **Novel Models for Quantifying Spatial Variability in Daily Precipitation Estimates.**

Propagating precipitation measurement variability and regional climate change scenarios into hydrological model forecasts is a major challenge and a significant source of uncertainty in understanding the water balance of the Great Lakes. A wide variety of models are available for quantifying precipitation variability across different spatial and temporal scales, however those with the greatest potential for supporting Great Lakes water supply and lake level management decisions explicitly quantify precipitation magnitude and variability. Here, we explore calibrated exponential dispersion models (EDMs) as a potential tool for addressing this need and estimating watershed-scale and over-lake precipitation estimates using a combination of weather station data and regional climate change scenarios. Our findings suggest that EDMs, when implemented in a Bayesian framework, are an ideal tool for supporting future regional precipitation trend assessments and for downscaling regional climate scenarios into local--scale rainfall time series simulations. These simulations, when compared to conventional precipitation estimates, lead to changes in projected Great Lakes net basin supplies, lake levels, and associated management decisions. *Keywords: Water level fluctuations, Climatic data, Hydrologic cycle.*

GUILDFORD, S.J., HOUSE, G.L., PEVAN, T., VAN DER WERFF, J.M., and HECKY, R.E., Large Lakes Observatory, University Minnesota Duluth, Duluth, MN, 55812.
Seasonal development and spatial extent of the deep chlorophyll layer in Lake Superior.

Lake Superior is the most oligotrophic of the Laurentian Great Lakes. The Deep Chlorophyll Layer (DCL) may provide an important contribution to primary productivity but its seasonal development and spatial extent are poorly defined. In 2010, the warmest year on record for the lake, a FluoroProbe spectral fluorometer was deployed on five cruises covering all regions of Lake Superior from June through September. The DCL developed in the lower metalimnion at depths between 20 and 40 m where temperatures were 4 to 6 C appearing first in the shallower far western basin in early June. In the remainder of the lake it was well developed by late July and persisted though late August when fall cooling began to deepen the mixed layer. Early in the season "green" algae were dominant in the DCL but were succeeded by "diatoms". By late August "diatoms" were completely dominant at all stations except the eastern basin where phycoerythrin containing phytoplankton were a significant contributor to the DCL. At the seasonal maximum total in situ chlorophyll concentrations in the DCL were similar at 2.5 to 3.0 micrograms per litre. The DCL was spatially extensive, reached a maximum in late summer and exhibited a well defined seasonal succession of algal groups across Lake Superior. *Keywords: Lake Superior, FluoroProbe, Phytoplankton, Deep Chlorophyll Layer.*

GYAWALI, R. and WATKINS, D.W., Michigan Technological University, Houghton, MI, 49931. **A comparision of two hydrologic modeling approaches for the Great Lakes watersheds: A case study of the Kalamazoo River basin.**

A surface water hydrology model of - the Kalamazoo River watershed in Michigan is developed. Rainfall-runoff characteristics, stream-flow and base-flow are simulated at a daily time step using the continuous soil moisture accounting algorithm in the Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS). The HEC-HMS model is calibrated, verified and recalibrated as a semi-distributed model with six sub-basins, each draining to a United States Geological Survey stream gage. The semi-distributed watershed model is then compared to the NOAA Large Basin Runoff Model (LBRM), a widely accepted hydrologic model in the Great Lakes region. It is seen from the comparison of results that the HEC-HMS model generally outperforms the area-scaled LBRM model at a sub-watershed scale, but at the expense of additional calibration effort. Examples of model predictions under future land use and climate change scenarios are also presented. Some of the limitations of common watershed models are identified for climate change studies, particularly computing evapotranspiration, sublimation and condensation on the snowpack. *Keywords: Great Lakes basin, Hydrologic budget, Model studies.*

HAACK, S.K.[1], FRANCY, D.S.[2], CORSI, S.R.[3], FOGARTY, L.R.[1], DURIS, J.W.[1], KEPHART, C.M.[2], BRENNAN, A.K.[1], ISAACS-COSGROVE, N.M.[1], JOHNSON, H.E.[1], and SPENCER, C.[1], [1]U.S. Geological Survey, Lansing, MI, 48911; [2]U. S. Geological Survey, Columbus, OH; [3]U.S. Geological Survey, Madison, WI. **Occurrence and Variability of Bacterial Pathogen Genes at Twelve Representative Great Lakes Beaches.**

The U. S. Geological Survey (USGS) conducted studies in 2010 to 1) identify physical and biological factors and land use variables, that influence bacterial pathogen gene and microbial source tracking (MST) marker occurrence, and 2) relate pathogen and marker occurrence to concentrations of *Escherichia coli (E. coli)* and enterococci fecal indicator bacteria (FIB). Thirty samples from each of 12 beaches on Lakes Michigan, Huron, and Erie, were collected by multiple local partners, at fixed intervals and also during or after environmental conditions such as high waves or rainfall. There was little relation among the gene markers of *Shigella* spp., pathogenic *Salmonella* spp., pathogenic *E. coli*, *Campylobacter jejuni* and *coli*, *Staphylococcus aureus*, and methicillin-resistant *S. aureus* (MRSA) to FIB concentrations at most beaches. The *Bacteroides* general and human MST markers and the *Catellicoccus* gull MST marker were detected infrequently. Urban land uses and soil type were associated with FIB concentrations, and environmental factors were related to occurrence of some pathogens. This study demonstrates the types of information required to improve understanding of microbial threats to the Great Lakes coastline. *Keywords: Microbiological studies, Human health, Coastal processes.*

HAGLEY, C.A.[1], FORTNER, R.W.[2], MANZO, L.M.[3], and AQUILAR, C.[4], [1]Minnesota Sea Grant, 31 W. College St., Duluth, MN, 55812; [2]Ohio State University, 113 Paula Circle, Oak Island, NC, 28465; [3]M. Westerville High School, 950 County Line Road, Westerville, OH, 43081; [4]Great Lakes Water Institute, 600 E. Greenfield Ave, Milwaukee, WI, 53204. **Great Lakes Research Meets Great Lakes Education: Learnings from the COSEE Great Lakes Summit.**

COSEE Great Lakes (Center for Ocean Science Education Excellence) is nearing the end of five years of NSF funding and has resulted in improved interaction and understanding among Great Lakes researchers and educators, new online and printed Great Lakes curricula, workshops and online Great Lakes courses for educators, Great Lakes Literacy Standards, and a "School for Scientists" to improve their incentive and ability to work with the public and education community. A culminating COSEE GL "Summit" was held in Fall of 2010 to review the progress and outcomes of this ambitious Center, draft summative papers for publication, examine the current realities of Great Lakes education and scientist involvement in broader impacts, and look to future opportunities to continue the momentum created through COSEE Great Lakes. Current and future needs related to Great Lakes education and scientists' comfort with broader impacts will be shared, along with recommendations and lessons learned.
Keywords: Education, Broader impacts of research, Great Lakes basin, Outreach.

HAMPTON, S.E.[1], KATZ, S.L.[2], IZMEST'EVA, L.R.[3], and MOORE, M.V.[4], [1]National Center for Ecological Analysis and Synthesis, University of California, Santa Barbara, CA, 93101; [2]Channel Islands National Marine Sanctuary, National Oceanographic and Atmospheric Association, Santa Barbara, CA, 93101; [3]Scientific Research Institute of Biology, Irkutsk State University, Irkutsk, Russia; [4]Department of Biological Sciences, Wellesley College, Wellesley, MA, 02481. **Long-term warming and variation of seasonal timing in Lake Baikal, Siberia.**

Long-term trends in warming occur in the context of short-term climate variability that can significantly affect local lake conditions. Lake Baikal in Siberia is the world's largest freshwater lake (by volume) and the earth's most biologically diverse lake, with many endemic cold-adapted species. The distinctive seasonal structure of the community may exhibit particularly strong responses to changes in average temperature and timing of seasonal transitions. We applied time-frequency analysis to a near-continuous, 58-year record of water temperature from Lake Baikal to examine dynamics of temperature over the past half century. Long-term warming was rapid and especially pronounced in summer, with concurrent increases in cladocerans and chlorophyll. On decadal scales, the timing of seasons strongly corresponds with fluctuating zonal wind intensity as described by length of day (LOD); on shorter scales, these temperature patterns shift with the El Nino-Southern Oscillation (ENSO), and this ENSO-Baikal connection is gated by the cool and warm periods of the Pacific Decadal Oscillation (PDO). These climate teleconnections are consistent with dynamics of the jet stream trajectory and associated storm track variability in central Asia and across the Northern Hemisphere. *Keywords: Atmosphere-lake interaction, Climate change, Ecosystems.*

HANRAHAN, J.L., KRAVTSOV, S.V., and ROEBBER, P.J., University of Wisconsin - Milwaukee, Dept. of Mathematical Sciences, Atmospheric Sciences group, P.O. Box 413, Milwaukee, WI, 53201. **Identification of Multidecadal Variability in the Outflow-Removed Water Levels of Lake Michigan-Huron.**

The water levels of the Laurentian Great Lakes exhibit variability at a wide range of temporal scales. These range from the relatively predictable seasonal cycle, to recently discovered near-decadal periodicities, to the seemingly random multidecadal variations. Understanding the longer-term and greater-magnitude variability is of particular interest due to its effect on shipping, hydroelectric power supplies, and recreation. In this study, we examine the Michigan-Huron lake-level time series after removing the damping effects of the system's outflow. This exposes the full lake-level variability associated with changes in regional precipitation which we have determined to be the primary lake-level driver. Integration of the lake-level changes after removal of the outflow, produces a time series which illustrates the lake-level behavior that would be observed if the outflows were constant, and not dependent on the levels themselves. This new outflow-removed lake-level time series exhibits significant multidecadal variability, which is likely associated with precipitation changes, linked to various phases of the Atlantic

Multidecadal Oscillation (AMO). While the previously identified near-decadal cycles have distinct seasonality, it appears that the AMO signal is present throughout the year. *Keywords: Water level fluctuations, Precipitation, AMO, Lake Michigan, Lake Huron.*

HANRAHAN, J.L. and KRAVTSOV, S.V., University of Wisconsin - Milwaukee, Dept. of Mathematical Sciences, Atmospheric Sciences group, P.O. Box 413, Milwaukee, WI, 53201. **Interdecadal Cycles of Lake Michigan Water Levels.**

Mapping and dating of strand-plain locations around Lake Michigan provides estimates of the time intervals between consecutive lake-level maxima. Consistent with previous analyses, this study revealed a preferred ridge-formation timing of about 33 years, indicating that the water levels have exhibited this interdecadal variability. To determine whether this time scale is associated with an oscillatory signal, we constructed a non-oscillatory red-noise model based on the instrumental record, ridge growth, and isostatic rebound rates. We then generated multiple time series of synthetic ridge data and computed the Probability Density Functions (PDFs) of resulting intervals between synthetic lake-level maxima. From this analysis, we found that the observed ridge timing's PDF based on all locations is within the 95% spread of synthetic PDFs, indicating that the null hypothesis, which states that the actual ridge data are consistent with the red-noise process and thus have an aperiodic character, cannot be rejected. The investigation of individual strand-plain locations, however, did reveal some statistically abnormal densities, hinting to a lake-level periodicity further supported by spectral analysis of the instrumental record. These results are used to comment on the issues associated with uncertainty in geophysical data sets. *Keywords: Water level, Water level fluctuations, Lake Michigan.*

HAPONSKI, A.E., MURPHY, D.M., and STEPIEN, C.A., 6200 Bayshore Rd., Oregon, OH, 43616. **Temporal and Spatial Genetic Patterns of Lake Erie Walleye Spawning Groups.**

Defining genetic stocks of walleye and understanding their spatial and temporal patterns may provide critical data for conservation and management. We test the genetic composition of Lake Erie walleye spawning runs (1) spatially from 11 primary spawning sites, (2) temporally from the 1995-2010 runs at 3 sites, (3) between the sexes, (4) among age cohorts, (5) across the temporal course of an individual run, and (6) between larval versus adult gene pools. We test a total of 1213 individuals using 9 nuclear microsatellite loci. Analyses include pairwise divergences, AMOVA partitioning, 3-D factorial correspondence, and Bayesian assignment tests. Results show that (1) most spawning sites genetically diverge, with closer relationship along the southern shore, especially between the Maumee and Sandusky River runs in the western basin, (2) the genetic composition within walleye runs is mostly consistent, with some annual stochasticity, (3) does not differ between sexes, (4) among age cohorts, or (5) timings of return. Our study thus shows that a single year "snapshot" of walleye spawning groups may not adequately characterize their overall genetic connectivity and divergence patterns, illustrating the

importance of understanding temporal and spatial stock structure to assist fisheries management. *Keywords: Lake Erie, Genetics, Walleye.*

HARGAN, K.E.[1], PATERSON, A.M.[2], and DILLON, P.J.[3], [1]Paleoecological Environmental Assessment and Research Lab (PEARL), Queen's Univ. Dept. Biology, 116 Barrie St., Kingston, ON, K7L 3N6; [2]Ontario Ministry of the Environment, Dorset Environmental Science Centre, 1026 Bellwood Acres Road, Dorset, ON, K7L 3N6; [3]Chemistry Department, Trent University, 1600 West Bank Dr., Peterborough, ON, K9J 7B8. **A total phosphorus budget for the Lake of the Woods.**

The Lake of the Woods (LoW) is a large (385,000 ha), freshwater lake that is located within the boundaries of the provinces of Ontario and Manitoba and the state of Minnesota. The overall goal of this study was to quantify the major and minor phosphorus (P) sources to and losses from the LoW, summarized as a nutrient budget. The LoW nutrient budget shows that currently, there is only a small total P contribution from shoreline developments (6 t;~1%), relative to the large P loads from atmospheric deposition (95Â±55 t; 13%) and the primary tributary, the Rainy River (568Â±155 t; 75%). Overall, the annual gross TP load to the LoW was between 714 to 813 t with 45 to 66% of the gross TP load retained within the lake. The nutrient budget for the Rainy River catchment revealed that contributions from point sources along the river constitute the largest anthropogenic total P source to the LoW rather than shoreline development. These TP budgets provide insights into the major sources of TP influencing the overall LoW water quality and with future refinement may provide a greater understanding of linkages between TP loading and spatial and temporal water quality changes in the LoW. *Keywords: Nutrients, Pollution sources, Water quality.*

HARKE, M.H.[1], DAVIS, T.W.[2], BERRY, D.L.[1], and GOBLER, C.J.[1], [1]Stony Brook University, School of Marine and Atmospheric Sciences, Stony Brook, NY, 11794; [2]Australian Rivers Institute, Griffith University, Nathan, Queensland, 4111, Australia.
Molecular Analysis of *Microcystis aeruginosa*: Dynamics of Toxic and Non-toxic Strains and Response to Phosphorus Limitation.

Despite extensive phosphorus (P) management programs, microcystin-producing blooms of *Microcystis aeruginosa* have become commonplace in many freshwater ecosystems including Lake Erie, USA. For this study, we used gene quantification to examine: 1. The dynamics of toxic and non-toxic strains of *Microcystis* using the microcystin synthetase gene, *mcyD*; 2. P acquisition in *Microcystis* examining high affinity phosphate binding proteins, *pstS* and *sphX*; and 3. Alkaline phosphatase activity examining *phoX*. Ecosystem studies demonstrated that toxic strains of *Microcystis* were promoted by inorganic phosphorus (P) more frequently than non-toxic strains, suggesting toxin synthesis may encumber toxic strains with a larger demand for nutrients. Culture experiments showed that the expression of the genes *pstS*, *sphX*, and *phoX* in *Microcystis* was regulated by inorganic P availability, but not P source, and that gene expression coincided with the induction of enzymatically measured alkaline phosphatase activity.

These data highlight the utility of gene markers for tracking the dynamics and physiology of *Microcystis* and specifically indicate the molecular level response of this cyanobacterium to differing P sources and concentrations. *Keywords: Microcystis, Phosphorus, Genetics.*

HARRISON, J.W. and SMITH, R.E.H., University of Waterloo, Waterloo, ON. **Effects of UV Radiation on Lake Ontario Phytoplankton Photosynthesis.**

Concentrations of dissolved organic carbon in Lake Ontario are low, and levels of suspended particles have decreased in recent decades due to the introduction of filter-feeding dreissenid mussels and controls on phosphorous loading. In these clear waters, planktonic organisms are exposed to potentially damaging levels of ultraviolet radiation (UVR) for much of the photoperiod. We investigated how UVR affects phytoplankton photosynthesis on diurnal and intra-seasonal timescales at a near-shore site in Lake Ontario during the summer of 2008. Photoinhibition was quantified as decreases in the variable fluorescence of Photosystem II (i.e. Fv/Fm) and the contributions of damage and recovery processes resolved by fitting experimental data to simple nonlinear models. Biological weighting functions were derived to capture the spectral-dependence of UVR-induced damage, and revealed that the phytoplankton communities we assessed were relatively resistant to PAR (400 - 700 nm) and UVAR (320 - 400 nm) but very sensitive to UVBR (280 - 320 nm). How nutrient status, taxonomy and climatic factors interact to influence the magnitude of photoinhibition experienced by phytoplankton in Lake Ontario is described. *Keywords: Photosynthesis, Ultraviolet radiation, Phytoplankton.*

HART, D.A.[1] and VENTURA, S.J.[2], [1]Room 201, Goodnight Hall, 1975 Willow Dr., Madison, WI, 53706; [2]Room, 433 King Hall, 1525 Observatory Drive, Madison, WI, 53706. **The Wisconsin Coastal Atlas: Building the Coastal Spatial Data Infrastructure to Promote Sustainable Management of the Great Lakes.**

The Wisconsin Coastal Atlas (http://www.wicoastalatlas.net/) is a new initiative by the University of Wisconsin Sea Grant Institute and its partners to provide access to maps, data, and tools to support decision-making about the Great Lakes. It is organized into four useful sections - maps, catalog, tools, and learn. A gallery of web mapping interfaces provides customized perspectives related to specific coastal issues in Wisconsin. Users can search for geospatial data through an interface that connects to distributed catalogs maintained by other coastal data custodians. The atlas serves as a gateway to spatial decision support tools relevant to Great Lakes management and provides a means to learn more about coastal issues and places. The initial focus of the atlas is on coastal hazards, but it is built with an open architecture that allows addition of new tools and components over time. Besides building the framework for the atlas, the project also tackles important research topics that address the science needed to effectively build and link coastal web atlases. This presentation will share the strategy used to build the atlas, examine different ways the atlas can be used, and explore how

individual coastal web atlases can be networked for the Great Lakes region.
Keywords: Decision making, Atlas, Coasts, Wisconsin, GIS.

HART, D.A.[1], HAGLEY, C.A.[2], and WORTLEY, A.J.[3], [1]1975 Willow Dr,, Goodnight Hall, Room 201, Madison, WI, 53706; [2]31 West College Street, Duluth, MN, 55812; [3]550 N. Park St., Science Hall, Room 384, Madison, WI, 53706. **Great Lakes Mapping Mashups: Promoting Data-Driven Decision-Making for the Great Lakes.**

The Great Lakes Observing System has reached a level of maturity where the website (http://glos.us/) now includes useful data and mapping products, with more in the works. Great Lakes Mapping Mashup workshops, held in 2009-2011 (http://www.greatlakesmashups.net/) used a novel approach to assessing need and improving capacity for mapping and data visualization products. Great Lakes managers and decision-makers were taught how to integrate maps and data "on-the-fly" to develop their own decision-making tools. We show that with a little training to provide knowledge about software tools and access to map and data services, it is possible to extend the use of innovative web mapping applications to multiple Great Lakes constituencies, providing them with the resources and knowledge to better utilize these tools for sustainable management of the Great Lakes. This presentation describes the workshops that were held on each of the Great Lakes and the webinar series hosted by Conservation Ontario. We describe the resources produced by the project (e.g., tutorials, applications of social media, dashboards), present results of an evaluation of effectiveness, and provide recommendations for future work. *Keywords: Decision making, GLOS, Observing systems, Mashups, GIS, Outreach.*

HATT, C.[1], LESHKEVICH, G.[2], SHUCHMAN, R.A.[1], and SAYERS, M.J.[1], [1]3600 Green Court, Suite 100, Ann Arbor, MI, 48105, US; [2]4840 S. State Rd, Ann Arbor, MI, 48108, US. **Estimation of Absorption and Backscatter Values from In Situ Radiometric Water Measurements.**

Water color remote sensing algorithms for case II waters like the Great Lakes require accurate characterization of the inherent optical properties (IOPs) within the water column to successfully estimate concentrations of chlorophyll (chl), dissolved organic carbon (doc), and suspended minerals(sm). IOP coefficients (i.e. absorption and backscatter) necessary to create hydro-optical(HO) models for each of the Great Lakes can be measured directly using expensive in situ instrumentation (such as ac-s and bb9) or derived from in situ radiometric measurements of light entering and exiting the water surface (ie. Ed and Lu) . We have utilized data collected from a Satlantic Profiling Radiometer and the MODIS satellite to generate through a model, absorption and backscatter values for CHL, and SM and absorption for the visible portion of DOC (CDOM) for data collected in 2010 on Lakes Michigan and Huron. These calculated values were then compared to coincident in situ measurements of the absorption and backscatter for the three parameters. *Keywords: Measuring instruments, Remote sensing, Lake Michigan.*

HECKATHORN, S.A., CHAFFIN, J.D., BRIDGEMAN, T.B., MISHRA, S., and KUHANECK, R.M., Dept. of Environmental Sciences and Lake Erie Center, Univ. of Toledo, 2801 Bancroft St, Toledo, OH, 43606. **Growth Rate and Lipid Production of *Fragilaria crotonensis* under different Nutrient, Salinity, and Temperature Levels.**

Our lab has been conducting experiments to determine the feasibility of using Lake Erie algae for biofuel production. *Fragilaria crotonensis* is often the second-most-abundant diatom in western Lake Erie. *F. crotonensis* was isolated from a Lake Erie water sample and cultured in the lab. Batch-culture experiments were used to study the effects of temperature, salinity, and nutrient concentration on growth rate and lipid production. Salinity (specific conductivity 0.3-30 mS/cm) and temperature (10-30C) growth-rate (μ) experiments were conducted in a high-nutrient media. μ increased with temperature to 20C and decreased with increasing salinity. Maximum μ was 0.65/day at 30C and at low salinity; however, μ was statistically similar between 20 and 30C. Across a gradient (0.00001 mM-1 mM) of silica (Si) and nitrate (N), μ exhibited half-saturation at 0.00143 mM Si and 0.00072 mM N. Lipid content was determined after growing *F. crotonensis* in combinations of high and low N and Si at 10C, 20C, and 30C. These results indicate that *F. crotonensis* is potentially useful in oil-based biofuel production. *Keywords: Biofuel, Lipid, Diatoms.*

HERNANDEZ, M.M. and BARTON, D.R., University of Waterloo, Department of Biology, 200 University Avenue, West, Waterloo, ON, N2L 3G1. **Growth Response of *Chara* to Phosphorus and Nitrogen enrichment.**

Laboratory experiment was carried out to examine the growth response of *Chara* in relation to nutrient enrichment. While many studies have demonstrated the toxic effects of Phosphorus (P), very few studies have investigated the toxic effects of Nitrogen (N) on *Chara*. Moreover, interactive effects of P and N on the growth of *Chara* are insufficient. Two-way factorial experiment with two levels of P (0.0052 and 0.0221 mg/L) and two levels of N (0.32 and 0.72 mg/L), respectively, was set-up. We found negative effects on the growth (total length and biomass) of *Chara* at high concentrations of N concomitant with low concentrations of P. On the contrary, there is a significant increase on the growth of *Chara* at high concentrations of P with low concentrations of N. The result suggests that N is in fact, inhibits the growth of *Chara*. *Keywords: Lake Huron, Eutrophication, Algae.*

HERRERA, L.S.[1] and BRADY, V.J.[2], [1]University of Minnesota Duluth Water Resources Science, 5013 Miller Trunk Hwy, Duluth, MN, 55811; [2]Natural Resources Research Institute University of Minnesota Duluth, 5013 Miller Trunk Hwy, Duluth, MN, 55811.
Using North Shore Streams and Benthic Macroinvertebrates to Develop an Indicator of Stream Impairment due to Excess Sediment.

Fine sediments (sand, silt, and clay) present a growing problem for streams around the Great Lakes. The effect can be seen in stream biotic communities. Macroinvertebrates, due to their life cycle length and species diversity, provide an ideal study organism to examine the effects of sediments on streams. Previous studies link particular macroinvertebrate traits with fine sediments, but are not diagnostic. 22 Lake Superior streams between Duluth and Grand Marais, Minnesota, were sampled throughout summer 2010. Substrate embeddedness, particle size, substrate cover in quadrats, and Wolman pebble counts were measured in conjunction with rainfall amounts and current velocity. Macroinvertebrates were quantitatively collected from riffles in late summer. Site riffle embeddedness ranged from 0 to 25%, with median particle sizes ranging from 13 to 280 mm. Median particle size calculated from Wolman pebble counts or quadrat percent cover estimates were reasonably correlated, but a breakdown in substitutability occurred one standard deviation away (D16 and D84). Sediment characteristics are being correlated with various macroinvertebrate characteristics and will form the basis for a biotic indicator. The biotic indicator will allow assessment of stream invertebrate condition as it relates to excess sediments.
Keywords: Macroinvertebrates, Sediment load, Indicators.

HINDERER, J.M. and GLASSNER-SHWAYDER, K., Great Lakes Commission, 2805 S. Industrial Hwy., Suite 100, Ann Arbor, MI, 48104. **Regional Symposium to Build Capacity for the Management and Control of Phragmites australis.**

Phragmites australis is a non-native plant that is negatively impacting many areas in the Great Lakes region. This invasive species commonly inhabits coastal and interior wetland and upland habitats, quickly forming tall, dense stands that crowd out native plants and animals. Invasive phragmites also impairs human uses by blocking views and limiting access. The need has emerged for a comprehensive and systematic approach to phragmites management and control across the state of Michigan, as well as region wide. The Great Lakes Commission has received funding from the Michigan Department of Natural Resources and Environment's Coastal Management Program to develop a strategic framework to advance a coordinated approach to phragmites management and control in Michigan, with relevance to the entire Great Lakes region. The framework will be guided by outcomes from a regional invasive phragmites symposium, to be held in Lansing on March 28-30, 2011, and a comprehensive management questionnaire. Our presentation will synthesize and summarize the current state of phragmites management in Michigan by presenting information gathered through the questionnaire and symposium. There will also be discussion on the initial stages of development of the strategic framework, based on input from a multi-stakeholder planning team.
Keywords: Invasive species, Policy making, Management.

HLADYNIUK, R. and LONGSTAFFE, F.J., University of Western Ontario, 1151 Richmond Street, London, ON, N6A3K7. **A stable carbon-isotope record of biogenic carbonate from Lake Ontario since >12.3 ka BP.**

Ostracodes (*C. subtriangulata, F. caudata*) and *Pisidium* sp. clam shells from Lake Ontario have stable carbon-isotope compositions ranging from -9 permil (*C. subtriangulata*) in the oldest sediments collected (>12.3 ka BP) to +1 permil (clams) in the youngest (~4 ka BP). The oldest ostracodes (>11.5 ka BP) are depleted of carbon-13 in sub-basins from west to east: Niagara, -3.5 permil; Mississauga, -5.5 permil; Rochester, -6.5 permil. After ~11.5 ka BP, the composition of *C. subtriangulata* stabilized at -4 to -3 permil until its abundance declined. *F. caudata* and clams then dominated, with compositions rising to +1 permil by ~4 ka BP. The carbon-isotope compositions of the oldest ostracodes coincide with glacial meltwater dominance (oxygen-isotope composition, -18 permil) at >11.5 ka BP. The range in ostracode compositions across the basin at this time likely reflects variations in DIC sources. Increasing *C. subtriangulata* abundance between 11.5-10 ka BP caused productivity-related carbon-13 enrichment of its valves as glacial meltwater influence lessened. *C. subtriangulata* declined sharply after 10 ka BP, as the region warmed and glacial meltwater disappeared. *F. caudata* and clams filled this niche as productivity rose during the Holocene Thermal Maximum. *Keywords: Lake Ontario, Ostracodes, Isotope studies, Clams, Geochemistry, Carbon.*

HOBMEIER, M.M., YOUSEF, F., LEDUC, J.F., and KERFOOT, W.C., Michigan Technological University, Department of Biological Sciences and Lake Superior Ecosystem Research Center, Houghton, MI, 49931. **Inland spiny water flea (*Bythotrephes longimanus*) dispersal and impacts on zooplankton communities.**

We show that *Bythotrephes longimanus*, an invasive cladoceran from Northern Europe, is rapidly spreading through the northern Great Lakes region along a temperature-dependent latitudinal band. *Bythotrephes* is a voracious predator, and individuals consume up to 40 smaller invertebrates per day (Grigorovich et al., 1998). Though the species is characterized by a large spine, providing protection from small fish, it also produces unusually thick shelled resting eggs that can pass through fish guts in viable condition. We conducted zooplankton surveys of inland lakes to document range expansion and follow zooplankton community makeup of invaded versus non-invaded lakes. Sediment cores from invaded lakes demonstrated assemblage shifts over a longer time scale. Additionally, gut contents from small fish seined in invaded lakes were analyzed for ingestion of egg carrying- *Bythotrephes*. Zooplankton community composition seems altered in invaded lakes, shifting dominance towards larger bodied or gelatinous cladoceran species. The transfer of baitfish from one lake to another apparently facilitates the spread of the spiny water flea, but there appears to be a temperature dependent geographic restriction. We suggest how control measures can limit further spread. *Keywords: Invasive species, Bythotrephes longimanus, Spatial distribution, Zooplankton communities, Paleolimnology.*

HOFFMAN, J.C., KELLY, J.R., PETERSON, G.S., and COTTER, A.M., US EPA Mid-Continent Ecology Division, 6201 Congdon Blvd, Duluth, MN, 55804. **Forging the link: using a conservative mixing framework to characterize connections between rivers and Great Lakes in river-lake transition zones.**

River-to-Great Lake transition zones are hydrologically, biogeochemically and biologically dynamic areas that regulate nutrient and energy fluxes between rivers and Great Lakes. Our goal is to characterize the biogeochemical properties of the river-lake transition zones and understand their relationship to food webs. We focused our initial research on south shore Lake Superior tributaries of contrasting geomorphology and land use. Differences along the transition zone were described using a conservative mixing model that is based on the geochemical gradient that arises from river and lake water mixing. We found that the upstream displacement of the transition zone varied with respect to both tributary morphology and discharge. Organic matter and nutrient sources to transition zones reflect anthropogenic activity within the watershed. Principal components analysis revealed that variability in nutrients and particulates along the transition zone is strongly influenced by physical mixing of river and lake water; however, deviations from conservative mixing reveal internal sources of nutrients and phytoplankton within mixing zones, indicating metabolic 'hot spots'. Stable isotope gradients that arise from the mixing of river and lake water can be used to connect areas of high productivity to higher trophic levels. *Keywords: Coastal wetlands, Stable isotopes, Tributaries, Biogeochemistry.*

HOLECK, K.T.[1], RUDSTAM, L.G.[1], JOHANNSSON, O.E.[2], BOWEN, K.[2], LANTRY, J.R.[3], CONNERTON, M.J.[3], and WALSH, M.G.[4], [1]Cornell Biological Field Station, 900 Shackelton Point Rd, Bridgeport, NY, 13030; [2]Great Lakes Laboratory for Fisheries and Aquatic Sciences, 867 Lakeshore Rd, Burlington, ON, L7R 4A6; [3]NYSDEC Cape Vincent Fisheries Station, 541 East Broadway, P.O. Box 292, Cape Vincent, NY, 13618; [4]USGS Lake Ontario Biological Station, 17 Lake St, Oswego, NY, 13126. **Timing of Changes in the Lake Ontario Lower Food Web.**

Change point analysis was used on Lake Ontario lower food web parameters (total phosphorus, chlorophyll *a*, zooplankton density, and zooplankton community composition) to examine potential relationships between observed changes and invertebrate stressors (*Dreissena* sp., *Cercopagis*, and *Bythotrephes*). Total phosphorus and chlorophyll *a* declined significantly from 1981 - 2009; both exhibited one step change in 1996. Offshore summer epilimnetic crustacean zooplankton density declined significantly from 1981 - 2009 at an average rate of 13% per year resulting in densities that are now 1% of historic levels; step changes in zooplankton density occurred in 1986, 1998, and 2005. Significant declines in bosminids and cyclopoid copepods were largely responsible for the step change in 2005. The step change in total phosphorus and chlorophyll *a* occurred at a time of increasing abundance of quagga mussels and decreasing abundance of *Diporeia* in the Lake Ontario offshore. Step changes in zooplankton density corresponded with the arrival of *Cercopagis* (1998) and the

proliferation of *Bythotrephes* (2005). Changes in the zooplankton community structure during the last decade are consistent with a decline in fish predation and an increase in invertebrate predation. *Keywords: Lake Ontario, Change point analysis, Zooplankton, Invasive species.*

HOLEM, R.R.[1], NEWSTED, J.L.[1], MATOUSEK, J.J.[1], TAZELAAR, D.L.[1], ROARK, S.A.[2], and KAY, D.P.[1], [1]Cardno ENTRIX, Okemos, MI, 48864; [2]ch2m hill, Brighton, MI, 48116. **Relationships between mercury and other common compounds of concern in fishes from the Saginaw Bay watershed.**

Select dibenzo-*p*-dioxin (PCDD), dibenzofuran (PCDF), and polychlorinated-biphenyl (PCB) congeners, mercury, arsenic, and a suite of other metals were measured in fillet tissue of more than 600 fish collected from the Saginaw Bay watershed in 2007 and 2008. Water bodies from which fish were collected included the Pine, Tittabawassee, Saginaw, Shiawassee, Flint, and Cass Rivers and the Saginaw Bay of Lake Huron. Species included channel catfish, carp, smallmouth, largemouth, and white bass, freshwater drum, northern pike, walleye, perch, crappie, and white suckers. Average concentrations of ΣPCDDs and ΣPCDFs ranged from 1.3 - 18 and 2.2 - 59 pg/g (ww), respectively, while average ΣPCBs ranged from 15 - 150 ng/g (ww). Concentrations of these were greatest in carp and channel catfish and generally least in freshwater drum. Interestingly, the greatest average mercury concentrations were observed in freshwater drum and the greatest average arsenic level in smallmouth bass. Approximately 7% of all mercury results exceeded the State of Michigan's mercury fish consumption advisory trigger level of 0.5 ppm. Relationships of the most commonly analyzed compounds in the data set will be examined on a species and location-specific basis. *Keywords: Lake Huron, Mercury, Walleye.*

HOLLENHORST, T.P.[1] and HUDSON, M.J.[2], [1]United States Environmental Protection Agency, 6201 Congdon Boulevard, Duluth, Duluth, mn, 55804; [2]Bad River Watershed Association, 101 W. Main Street # 353, P.O. Box 875, Ashland, WI, 54806. **Modeling Peak Discharge within the Marengo River Watershed - Developing priorities for Restoration.**

To better understand the hydrologic condition of the Marengo River Watershed, and to map specific locations most likely to have increased discharge and flow velocity (leading to more erosion and higher sediment loads) we modeled peak discharge for 35 different sub-watersheds delineated expressly for this purpose. This effort largely follows the approach used in the report; "Marengo River Watershed Test Case: Assessing the Hydrologic Condition of the Marengo River Watershed, Wisconsin" prepared by the Wisconsin Lake Superior Basin Partner Team. Just as the Marengo River Watershed Test Case modeled peak discharge for 5 Marengo River Sub-watersheds using the National Flood Frequency model, we modeled peak discharge specifically for these same 5 sub-watersheds and again for a higher resolution set of 30 sub-watersheds. We also refined the inputs to the model using GIS overlay techniques and area weighted averages. Our

initial results compared closely with the test case results with similar estimated discharge and rank order from lowest to highest discharge. The higher resolution set of 30 sub-watersheds was then used to execute the model, and to summarize the amount of open lands, allowing sub-watersheds with excessive discharge and relatively more open land to be identified. This abstract does not necessarily reflect USEPA policy.
Keywords: Watersheds, Hydrogeomorphology, Sediment load.

HOLLWEG, T.A., NOAA Restoration Center, I.M. Systems Group, Silver Spring, MD, 20910. **Monitoring and Evaluation of Coastal Habitat Restoration Projects in the Great Lakes Region.**

The mission of the NOAA Great Lakes Habitat Restoration Program (GLHRP) is to plan, implement, fund and/or direct coastal habitat restoration projects in the Great Lakes region. Monitoring and evaluation of these projects is necessary for assessing the effectiveness of the restoration actions, showing progress toward the desired goals of the project/program, and communicating project achievements to stakeholders and the public. The NOAA Restoration Center (RC) recognizes the importance of monitoring and evaluation, and strongly supports thier partners in this effort. To improve the planning, decision-making and effectiveness of the RC's programs, the RC is initiating a systematic framework for monitoring, evaluation and reporting, which includes 1) a consistent and targeted approach to monitoring and evaluation, 2) a platform for data capture/store/management to improve the efficiency of reporting, 3) a process for project/regional analysis of monitoring and evaluation information, and 4) the integration of this information into future project prioritization/implementation efforts. This presentation will provide an overview to current RC-funded monitoring and evaluation activities in the Great Lakes region and how these have helped structure our future approach. *Keywords: Assessments, Habitats, Restoration, Monitoring.*

HOLMAN, K.D. and NOTARO, M., Center for Climatic Research, University of Wisconsin - Madison, Madison, WI, 53706. **Understanding the Source of Monthly Variations in Great Lakes Water Levels.**

Changes in Great Lakes lake levels have important consequences for ecosystems, hydropower generation, and the shipping industry. Here we present an analysis of monthly lake level tendency (ΔL) for each of the Great Lakes between 1900 - 2008. Our results suggest that the tendency term is not normally distributed, with positive lake level tendencies occurring more frequently than negative lake level tendencies. We also show that the temporal distribution of anomalously positive lake level tendencies is different from the temporal distribution of anomalously negative tendencies, for each lake. The role of precipitation, evaporation, and runoff anomalies in determining lake level fluctuations is investigated. In addition, we utilize spatial composites of synoptic variables, such as sea-level pressure, geopotential height, and air temperature from the NCEP-NCAR V2 Reanalysis to understand how positive and negative lake level tendency conditions differ. The spatial composites demonstrate how differently each of

the Great Lakes responds differently to atmospheric circulations and conditions.
Keywords: Water level fluctuations, Atmosphere-lake interaction, Atmospheric circulation.

HONDORP, D.W., ROSEMAN, E.F., and MANNY, B.A., USGS-Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105. **The ecological basis for fish habitat restoration in the Huron-Erie Corridor.**

Habitat destruction and alteration is widely believed to be a major impediment to the restoration of native fish species in the Detroit River, Lake St. Clair, and St. Clair River, collectively known as the Huron-Erie Corridor (HEC). In this presentation, we describe the rationale behind ongoing and future fish habitat research related to the 2004 HEC initiative, whose purpose is to create relevant new science for the effective management of fish, wildlife, and their habitats in the HEC. First we provide a historical perspective on the HEC and the importance of this system as a case study for fish habitat research in Great Lakes connecting channels. We then justify our main science objective of developing diverse and complex habitats that encompass the ontogeny of habitat use and dispersal patterns of native fish species in the HEC. Finally, we discuss the scientific framework guiding the development of future research and rehabilitation priorities.
Keywords: Remediation, St. Clair River, Habitat, Detroit River.

HONDZO, M. and MISSAGHI, S., University of Minnesota - SAFL, 2 Third Ave. SE, Minneapolis, MN, 55414. **Lake Minnetonka ELCOM-CAEDYM Ecological Modeling: Parameter Estimation, Sensitivity, and Uncertainty Analysis.**

Three dimensional (3D) hydrodynamic and ecological models extend our understanding of morphologically complex aquatic systems. One of the issues with complex models is what confidence can we have in the numerical results? We used model parameter estimation, calibration, corroboration, and two sensitivity and uncertainty analyses to qualitatively answer that question. We will share results of the two sensitivity analyses methods and model parameter ranking of the most influential and highly ranked model parameters that the model is most sensitive to. Seventy percent of the total model output was explained by 4 top ranked model parameters in one method and 7 parameters by the second method. The model outputs of temperature, dissolved oxygen, and algae biomass contributed 3, 13, 26, and 58% to total model variance respectively. The results were corroborated by calculating the sensitivity index of 29 evaluated parameters. The Chla output sensitivity was shown to be spread over a larger number of parameters, with almost 40% of the variance depending on all other less ranking parameters. The analysis highlighted the need for a greater understanding and measured values of biological model parameters. The findings also highlighted the value of configuring the bacteria and zooplankton modeling in future simulations.
Keywords: Lake model, Model studies, Computer models.

HOOK, S.J. and SCHNEIDER, P., NASA/Jet Propulsion Lab., 4800 Oak Grove Drive, Pasadena, CA, 91109. **Global Trends in Lake Surface Temperatures Estimated From Thermal Infrared Satellite Imagery.**

Several in-situ studies have recognized that the temperature of lakes and other inland water bodies is a good indicator of climate variability and more recently that certain lakes appear to be warming more rapidly than nearby air temperatures. Here we present results from utilizing spaceborne thermal infrared imagery to generate multi-decadal time series of lake surface temperature for approximately 150 of the largest lakes in the world. The data used for this purpose includes imagery from the Advanced Very High Resolution Radiometers (AVHRR), the series of (Advanced) Along-Track Scanning Radiometers ((A)ATSR), and the Moderate Resolution Imaging Spectroradiometer (MODIS). Used in combination, these data sets offer a continuous time series of daily to near-daily thermal infrared retrievals from 1985 through present. We present results of an extended global study of worldwide trends in lake temperatures, indicating that the majority of lakes studied have warmed significantly over the last few decades. We further discuss distinct regional patterns in these trends and how they relate to spatial patterns in recently observed global air temperature increase. The research provides a unique, global-scale, and consistent perspective on the temporal thermal properties of large inland water bodies worldwide. *Keywords: Climatology, Remote sensing, Satellite technology.*

HORNE, A.[1], BOASE, J.C.[1], MANNY, B.A.[2], THOMAS, M.V.[3], and MOHR, L.[4], [1]Alpena Fish and Wildlife Conservation Office, Waterford Substation, 7806 Gale Rd., Waterford, MI, 48327; [2]USGS Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105; [3]Michigan Department of Natural Resources, Mount Clemens Fisheries Research Station, 33135 South River Rd., Mt. Clemens, MI, 48045; [4]Ontario Ministry of Natural Resources, 1450 Seventh Ave. E., Owen Sound, ON, N4K 2Z1. **Lake Sturgeon Movements Associated with Spawning in a Deepwater Great Lakes Connecting Channel.**

Lake Sturgeon populations remain at about 1% of pre-European settlement in the Great Lakes. The largest remaining free ranging population within the Great Lakes spawns in the Huron-Erie Corridor in headwaters of the St. Clair River near Port Huron (MI). In 2002-2004 14 Lake Sturgeon were implanted with ultrasonic transmitters to assess movements associated with spawning at the Port Huron Reef. Ten of 14 implanted Lake Sturgeon exhibited atypical migration patterns by migrating downstream from Lake Huron to spawn. The 4 remaining fish migrated back to either the lower St. Clair River or Lake St. Clair. Lake Sturgeon location data collected near the reef was used to identify spawning habitats during the spawn and staging areas prior to and after the spawn. Geo-referenced underwater video was used to determine the spatial extent and physical characteristics of habitats used. Fish used large underwater obstructions as refuge areas likely due to reduced current velocities. Deepwater (>15m) spawning habitat was dominated by pebble and cobble size substrates ranging from 2-50 cm diameter. No fine substrates were found throughout the 59 ha. spawning area. The downstream movement of fish from Lake Huron to the Port Huron reef suggests a behavioral trait that is not

observed in other Lake Sturgeon populations within the Great Lakes. *Keywords: Fish, Life history studies, Lake Sturgeon, St. Clair River.*

HORNS, W.H., Wisconsin Department of Natural Resources, 101 S. Webster St., Madison, WI, 53707. **Early detection and rapid response may not be smart.**

The strategy of early detection and rapid response (EDRR) is often held up as a self-evidently reasonable approach to combating invasive species. Recently, Vander Zanden et al. (JGLR 36, 2010) published an explicit argument for a version of EDRR called "early detection and eradication" for invasive species brought to the Great Lakes in ships ballast. The program would identify and monitor a selected group of vulnerable habitats and ballast discharge events across the Great Lakes basin, focusing on the most probable invaders, the most invasion-prone habitats, and the potential invaders most conducive to eradication. The program would allow quick action when a problematic and eradicable species is found. I argue that this is an unwise strategy. I ask, What is the likelihood that we would truly be in the presence of an eradicable and problematic invader when we think we have detected one? Using Bayes Theorem it is possible to estimate that probability in terms of the plausible values of other more accessible probabilities. When we do so it becomes apparent that the odds are strongly against success and in favor of implementing damaging, costly, and futile eradication measures. *Keywords: Early detection and eradication, Invasive species.*

HOST, G.E.[1], AXLER, R.P.[1], SILBERNAGEL, J.[2], DANZ, N.P.[3], SCHULDT, J.A.[3], HART, D.A.[4], DREWES, A.[5], WAGLER, M.[6], MATHEWS, J.[6], HAGLEY, C.A.[7], and SCHOMBERG, J.[7], [1]Natural Resources Research Institute, University of Minnesota Duluth, Duluth, MN, 55811; [2]Nelson Institute for Environmental Studies, University of Wisconsin Madison, Madison, WI; [3]Natural Sciences Department, University of Wisconsin Superior, Superior, WI; [4]University of Wisconsin Sea Grant Institute, Madison, WI; [5]Save Our Rice Alliance, Bemidji, MN; [6]Local Games Laboratory, University of Wisconsin Madison, Madison, WI; [7]Minnesota Sea Grant, University of Minnesota, Duluth, MN. **Stressor Gradients and Spatial Narratives of the St. Louis River Estuary.**

The St. Louis River Estuary is a complex mosaic of high quality aquatic and riparian habitat intermingled with areas of heavy industrial use and effluents from an urban landscape. Communities surrounding the estuary are developing land use plans that will determine their future environmental and socioeconomic health, and it is important that decision makers have access to data, tools and technologies that provide for socially and ecologically sound decisions. Our project will provide an assessment of reference and at-risk aquatic habitats in the St. Louis River estuary to guide future monitoring, restoration, remediation, land use planning, along with community awareness and stewardship. This project characterizes water quality, and plant and macroinvertebrate communities along a watershed-based human stressor gradient, and uses the results to map reference and at-risk habitats. This gradient will also be used to develop spatial narratives through multifaceted land, ship, and Internet-based outreach and collaborative learning activities. Communication tools include an open geospatial archive, a 'deep map' that incorporates vignettes of local communities, augmented reality games and geo-tours of the estuary, ship-based activities, and a diverse array of complementary online resources @ www.StLouisRiverEstuary.org. *Keywords: Watersheds, Environmental effects, Outreach.*

HOST, G.E.[1], BROWN, T.N.[1], HOLLENHORST, T.P.[2], CIBOROWSKI, J.J.[3], JOHNSON, L.B.[1], and AXLER, R.P.[1], [1]Natural Resources Research Institute, University of Minnesota Duluth, Duluth, MN, 55811; [2]Environmental Effects Research Laboratory, US EPA Mid-Continent Ecology Division, Duluth, MN; [3]Biological Sciences Dept, University of Windsor, Windsor, ON. **A High-resolution, Scalable Index of Anthropogenic Stress for Great Lakes Watersheds.**

Linking human activities on the landscape with the health of aquatic ecosystems presents challenging issues of spatial scale, data resolution, and the confounding influence of historic and recent events. The development of GIS-based anthropogenic stressor gradients provides a means of linking watershed attributes with indicators of ecosystem health, including water quality and biotic measures. To address scale issues, we used ArcHydro, a hydrologic data model, to delineate fine-scale watersheds that retain hydrologic continuity. Anthropogenic stressors such as land cover, point sources, and human population were summarized for each subcatchment and combined into an integrated stressor index. Database tools were developed to accumulate these stressor values and indices for all of the upstream sub-catchments flowing to a particular location. The stressor gradient was used to stratify samples for water quality, wetland vegetation and macroinvertebrates in the St. Louis River estuary, the largest US contributing watershed to Lake Superior, an EPA Area of Concern, and focus of the newly designated National Estuarine Research Reserve. *Keywords: Lake Superior, Indicators, Water quality.*

HOUSE, G.L., GUILDFORD, S.J., and HECKY, R.E., Large Lakes Observatory, University of Minnesota Duluth, Duluth, MN, 55812. **Phytoplankton Photosynthetic Efficiency in the Deep Chlorophyll Layer (DCL) of Lake Superior during the Summer of 2010.**

As with many large lakes, during the summer in Lake Superior a Deep Chlorophyll Layer (DCL) forms below the stratified surface layer at depths ranging from 20 to 40 m. The contribution of DCL photosynthesis to the primary productivity of Lake Superior was measured repeatedly through the summer at four stations across the lake. A Fast Repetition Rate Fluorometer (FRRF) was used to take continuous depth profiles of variable chlorophyll fluorescence (Fv/Fm), an indicator of how efficiently phytoplankton use absorbed light energy to drive photosynthesis. During early summer the maximum Fv/Fm values were near the depth of the DCL. However by early August phytoplankton in a depth band (20 to 30 m) spanning the DCL had distinctly lower Fv/Fm values compared to phytoplankton at other depths, forming a "notch" in the pheophytin-corrected profile. By early fall the phytoplankton in the DCL had Fv/Fm values similar to the rest of the water column. Separate profile data from a spectral fluorometer (FluoroProbe) show distinct changes in phytoplankton pigment types through the summer, representing shifts in functional groups. The DCL in Lake Superior appears to be a zone of active photosynthesis where a combination of changes in nutrient availability and species composition may explain the variation in Fv/Fm values through the summer. *Keywords: Phytoplankton, Photosynthesis, Lake Superior.*

HOWELL, E.T.[1], BARTON, D.[2], and FIETSCH, C.[3], [1]Ontario Ministry of the Environment, 125 Resources Road, Toronto, ON, M9P 3V6; [2]University of Waterloo, Waterloo, ON, N2L 3G1; [3]Bruce Power, Tiverton, ON, N0G 2T0. **Where Did All the Algae Come From: the Unexplained *Chara* Fouling on the SE Shores of Lake Huron.**

Ongoing complaints of shoreline fouling in SE Lake Huron began around 2002. Unlike the lower Great Lakes where *Cladophora* predominates, multiple types of benthic algae contribute to beached biomass. In Lake Huron *Chara vulgaris* contributes strongly to shore fouling washing up erratically from spring to fall, over a range of locations, with limited spatial or temporal coherence. *Chara* grows in shallow water (<6 m) loosely rooted in sand and gravel seams among the cobble to boulder substrate of the shallow lakebed. Maximum biomass occurs at depths <2 m. *Chara* distribution does not appear to be related to nutrient regime, however, quantification of nutrients over complex shoreline is at best approximate. The reason for the apparent onset of *Chara* fouling in the past 10 years is unknown. Lines of investigation include: declining water level and changing habitat supply; changing nutrient regime associated with land runoff; and reduced grazing pressure due to round goby predation on benthic grazers. *Chara* fouling is frequently interpreted by the public as an indicator of declining water quality; explanation is required to aid in problem identification if fouling is attributable to adverse water quality or to guide public communication if it is due to ecological alterations. *Keywords: Algae, Lake Huron, Coastal ecosystems.*

HRABIK, T.R.[1], ISAAC, E.J.[1], GAMBLE, A.E.[1], YULE, D.L.[2], STOCKWELL, J.D.[3], GORMAN, O.T.[2], VINSON, M.R.[2], ROTH, B.M.[4], and SEIDER, M.J.[5], [1]University of Minnesota, Duluth Campus, 207 Swenson Science Build, 1035 Kirby Dr., Duluth, MN, 55812; [2]USGS Great Lakes Science Center, Lake Superior Biological Station, 2800 Lake Shore Drive East, Ashland, WI, 54806-2427; [3]Gulf of Maine Research Institute, 350 Commercial Street, Portland, ME, 04101; [4]Department of Fisheries and Wildlife, Michigan State University, 13 Natural Resources, East Lansing, MI, 48824; [5]Wisconsin Department of Natural Resources, 141 S Third Street, Bayfield, WI, 54814. **Prey Supply and Demand in Offshore Waters of Lake Superior: Does Diel Vertical Migration Stabilize Predator-Prey Interactions?**

Recent studies indicate that prey demand by top predators in Lake Superior is approaching carrying capacity. While the offshore waters (>80m)of Lake Superior are historically poorly understood, recent surveys provide data sets that now allow examination of trophic supply-demand in this region. We examined predatory demand of siscowet, the dominant offshore predator, relative to the production of prey in offshore areas in nine locations distributed lakewide in 2005. Comparisons of annual consumption by siscowet to the production of primary fish prey indicate a surplus production of coregonines (~12,500 MT), a deficit production of deepwater sculpin (4,100 MT) and a balance between production and consumption of rainbow smelt. Given that deepwater sculpin are the predominant diet item by biomass found in siscowet, our results indicate that deepwater sculpin populations may decline in the coming years. Furthermore, diel vertical migration (DVM) by coregonines may represent a mechanism that reduces interaction intensity with siscowet. Individual based model scenarios indicate a substantial reduction in siscowet growth under conditions with coregonines that exhibit DVM when compared to growth in environments with no coregonine movement. These simulations suggest that DVM behavior by coregonines may dampen interaction intensity. *Keywords: Predation, Lake Superior, Fish behavior.*

HU, D., MARTINEZ, A., and HORNBUCKLE, K.C., Department of Civil & Environmental Engineering and IIHR-Hydroscience and Engineering, The University of Iowa, Iowa City, IA, 52242. **Sedimentary Records of Non-Aroclor and Aroclor PCB mixtures in the Great Lakes.**

Three sediment cores from Lake Ontario, Lake Erie and Indiana Harbor Ship Canal were analyzed for Aroclor and non-Aroclor PCBs. PCBs associated with the commercial Aroclor mixtures 1248 and 1254 dominate the sediment signal and ∑PCB peaks in concentration and accumulation around 1970 in the Great Lakes. This trend is very similar to Aroclor production history. In the Indiana Harbor Ship Canal, PCBs appear around 1935 and remain at very high levels between 1940 and 1980, probably reflecting the history of use at the nearby steel mill. In contrast, the non-Aroclor PCBs in the Lake Ontario and IHSC sediment cores, including PCB11 and heavily chlorinated congeners PCB206, 207, 208 and 209 reach a peak in the 1950s, decline and peak again in the 1970s or in the early 1980s. PCB11 was found to peak about 5 years later than ∑PCBs, and is probably associated with the production or use history of diarylide yellow pigments. The temporal distribution profiles of these non-Aroclor PCBs are well correlated with the production history of paint pigments and dyes. Although it is well known that the production of Aroclor PCBs is preserved in Great Lakes sediments, this study is the first to show that production of non-Aroclors are also preserved in the sediments as a record of long term trends in environmental exposure. *Keywords: PCBs, Sediments, Environmental contaminants.*

HU, H.[1], WANG, J.[2], SCHWAB, D.J.[2], and LESHKEVICH, G.[2], [1]CILER, University of Michigan, 4840 South State Road, Ann Arbor, MI, 48108, USA; [2]NOAA Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108, USA. **Simulation of Lake Erie Ice from 2007 to 2010.**

A Great Lakes Ice-circulation Model (GLIM) was applied to Lake Erie to simulate ice and water circulation in Lake Erie annual cycle and yearly change during 2007-2010. The hourly surface wind stress and thermodynamic forcing for to the GLIM are derived from station measurements interpolated onto the 2-km grid. The seasonal variations for sea ice concentration, thickness, velocity, and other variables are well reproduced in the ice season. Satellite measurements of surface water temperature and ice cover, and ice thickness measured using a helicopter was used to validate GLIM. The annual cycle for the lake surface temperature is well reproduced. A series of sensitivity experiments further confirms the important impacts of ice cover on lake water temperature. *Keywords: Lake Erie, Ice, Model studies.*

HU, K. and CHEN, Q.J., Department of Civil and Environmental Engineering, Louisiana State University,, Baton Rouge, LA, 70803. **Directional Spectra of Extreme Waves.**

Directional and frequency distributions of extreme waves generated by hurricanes in the Gulf of Mexico are studied based on field measurements and numerical modeling. The directional wave data were collected at 12 buoys during eight hurricane events in recent years. A series of numerical experiments using a third-generation spectral wave prediction model were carried out to gain insight into the mechanics controlling the directional and frequency spreading of extreme wave energy. It is found that most of the hurricane-induced extreme wave spectra are swell-dominated except the right-rear quadrant of a hurricane with respect to the storm translation direction, where local strong winds control the spectra. Despite the complexity of a hurricane wind field, most of the spectra are mono-modal, similar to those under fetch-limited, unidirectional winds. However, bi-modal spectra were also found in both measurements and model results. Some of them are bi-modal in frequency with the same wave direction. This occurs when the energy of locally-generated wind sea is only partially transferred to the swell energy by non-linear wave-wave interactions. Some of them are bi-modal in both frequency and direction. This happens mainly in the left quadrants when the direction of hurricane winds deviates considerably from the swell direction. *Keywords: Tropical regions, Field observations, Waves, Extreme Waves, Model studies.*

HUBERTY, B.J., U.S. Fish & WIldlife Service, 1 Federal Drive; MS 4056, Ft Snelling, MN, 55111-4056. **Overview of Remote Sensing Applications and Needs for the Great Lakes.**

The U.S. Fish & Wildlife Service's Geospatial Habitat Cooperators (MTRI, UMN, SMU, Shated Geo, DU) as well as fellow federal, state, tribal, LGU and NGO's are developing a variety of new remote sensing assessment products to help restore the

Great Lakes now and into the future. This is supported in part by the Great Lakes Restoration Initiative. This presentation will highlight the current and future remote sensing activities for landscape and habitat assessment. The U.S. Fish and Wildlife Service's National Wetland Inventory (NWI) program is the focal point to work with international, federal, state, tribal, local governments and NGO partners across the basin to assess and measure our habitat and wetland maps to prioritize sensitive and restorable areas across the basin. This science-driven landscape assessment benefits on-the-ground habitat and wetland restoration, protection and creation projects in the face of climate change threats and human activities. *Keywords: Remote sensing, Geospatial, Habitats, Open source, Great Lakes basin, Sharedgeo.*

HUDSON, M.J. and DAMSTRA, V.A., Bad River Watershed Association, Ashland, WI, 54806. **The Marengo River Watershed Partnership: A Local Community Making a Great Lake Superior.**

The Bad River Watershed Association (BRWA) formed the Marengo River Watershed Partnership (MRWP) in 2009 as a way to connect local citizens, governments, and technical experts in creating a watershed action plan to maintain and improve the health of one of Lake Superior's largest sediment contributing subwatersheds. The project follows up on several years of work by Wisconsin's Lake Superior Basin Partner Team to highlight and implement a "slow the flow" management strategy. Slow the flow captures the concept that reducing the rate of surface runoff to streams in Wisconsin's Lake Superior Basin is the key to maximizing aquatic habitat and reducing sediment loads to Lake Superior. The presentation will look at the process used to engage local citizens, governments, and technical experts, examine some of the key challenges facing the Marengo River Watershed, look at some of the actions the MRWP has identified as priorities to maintaining and improving the health of the watershed, and show how local watershed groups can play an important role in meeting Lake Superior's Ecosystem Goals and "Make a Great Lake Superior." *Keywords: Non-governmental organizations, Lake Superior, Watersheds.*

HUNG, H.[1], SU, Y.[1], PARK, R.[1], JANTUNEN, L.[2], VENIER, M.[3], BASU, I.[3], BRICE, K.[1], BACKUS, S.M.[4], SVERKO, E.[5], BRADLEY, L.[4], HITES, R.A.[3], DRYFHOUT-CLARK, H.[2], and LEE, S.C.[1], [1]Air Quality Research Division, Environment Canada, 4905 Dufferin Street, Toronto, ON, M3H 5T4, Canada; [2]Centre for Atmospheric Research Experiments, Environment Canada, 6248 Eighth Line, Egbert, ON, L0L 1N0, Canada; [3]School of Public and Environmental Affairs, Indiana University, Bloomington, IN, 47405, US; [4]Water Quality Monitoring and Surveillance Division, Environment Canada, 867 Lakeshore Road, P.O. Box 5050, Burlington, ON, L7R 4A6, Canada; [5]National Laboratory for Environmental Testing, National Water Research Institute, 867 Lakeshore Road, P.O. Box 5050, Burlington, ON, L7R 4A6, Canada. **Temporal Trends in Atmospheric Deposition of Toxic Pollutants to the Great Lakes: 1992-2008 Loadings Estimates from the Integrated Atmospheric Deposition Network (IADN).**

IADN has been conducting air and precipitation measurements in the Great Lakes since the early 1990s. Gas, particle and precipitation phase samples are collected at 5 master stations: Point Petre on Lake Ontario, Sturgeon Point on Lake Erie, Burnt Island on Lake Huron, Sleeping Bear Dunes on Lake Michigan and Eagle Harbour on Lake Superior. Samples are analysed for organochlorine pesticides (OCPs), polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs) and trace metals. Combined with the physicochemical properties of the individual compound, water concentrations, meteorological data and physical information of the lakes, the measured concentrations form the basis for chemical deposition calculations. Atmospheric loading estimates of these chemicals were calculated each year from 1992 to 2008 for each of the five lakes taking into account wet deposition via precipitation, dry particle deposition and air-water surface exchange (absorption and volatilization). Loading estimates for banned OCPs continue to decline over time while current-use pesticide endosulfan showed more variable deposition trends. The influence of urban sources on the lakewide loading estimates was evaluated using the satellite sites of Chicago and Cleveland. Urban areas are found to be important sources of atmospheric PCBs to the Lakes.
Keywords: Deposition, Great Lakes basin, Pollutants.

HUNTER, T.S. and GRONEWOLD, A.D., Great Lakes Environmental Research Laboratory, National Oceanic and Atmospheric Administration, Ann Arbor, MI, 48108.
Variability and Uncertainty in Great Lakes Runoff Estimates.

Estimation of Great Lakes component-based net basin supplies requires accurate estimates of each of the three components (precipitation, runoff and evaporation). There are significant sources of uncertainty and variability in measurement for each of these parameters; however runoff estimates are believed to be a leading source of uncertainty because the observation network for streamflow runoff is sparse or non-existent in many parts of the Great Lakes basin. To address this problem, we examine several methods for estimating streamflow on a watershed basis, including unit flow interpolation, flow duration curves and other regionalization-based schemes. Basin-wide estimates are then computed from watershed estimates and the various methods are compared to show how variance in runoff estimates contributes to very different NBS estimates and, perhaps more importantly, has the potential for significant variability in resource management decisions. *Keywords: Hydrologic budget, Runoff, Lake Superior, Uncertainty.*

IVAN, L.N.[1], HOOK, T.O.[1], THOMAS, M.[2], and FIELDER, D.G.[3], [1]Purdue University, 195 Marsteller, West Lafayette, IN, 47907; [2]Michigan Department of Natural Resources & Environment, Lake St. Clair Research Station, Harrison Township, MI, 48045; [3]Michigan Department of Natural Resources & Environment, Alpena Great Lakes Fisheries Research Station, Alpena, MI, 49707. **Factors influencing yellow perch recruitment in Saginaw Bay, Lake Huron.**

Yellow perch are an important ecological species that has provided the basis for both commercial and recreational fisheries in Saginaw Bay, Lake Huron. Management of

this species is difficult, as catch rates and sizes of individuals captured vary annually. Importantly, yellow perch abundance has declined since 1970 despite recent record levels in age-0 production. Recruitment is highly variable, but mechanisms controlling recruitment remain elusive. We analyzed long-term trawl data (1970-2008) from the Michigan Department of Natural Resources to determine what factors influence yellow perch recruitment in Saginaw Bay. We developed stock-recruitment models with independent variables thought to be important to yellow perch recruitment and used Akaike's information criterion (AIC) to select the most parsimonious model. Independent variables included walleye abundance, growing degree days, spring temperature, annual river flow and total phosphorous load from the Saginaw River, and presence of dreissenids and Bythotrephes. This analysis will provide managers with insights into yellow perch recruitment. *Keywords: Environmental effects, Recruitment, Yellow perch.*

JACKSON, P.R.[1] and RICHARDS, K.D.[2], [1]USGS-Illinois Water Science Center, 1201 W. University Ave., Suite 100, Urbana, IL, 61801; [2]USGS-Iowa Water Science Center, 400 S. Clinton St.. #269, Iowa City, IA, 52240. **Synoptic Water Quality and Velocity Survey of Milwaukee Harbor and its Three Tributaries Using a Manned Boat and Autonomous Underwater Vehicle.**

In September 2010, the U.S. Geological Survey completed a synoptic water quality and water velocity survey of the Milwaukee inner and outer harbors and the three tributaries to the harbors-- the Milwaukee, the Menomonee, and the Kinnickinnic Rivers. The survey was completed to complement data from the National Monitoring Network. In addition, the survey was used to evaluate new technology for synoptic water-quality surveys and determine its applicability in long-term monitoring efforts. Survey methods included using a manned boat equipped with an acoustic Doppler current profiler (ADCP), differential GPS, and a profiling multiparameter water quality sonde. In addition, an autonomous underwater vehicle (AUV) equipped with the same suite of water quality sensors, an ADCP, differential GPS, and side scan sonar was used. Results from the AUV survey are encouraging and provide valuable insight into the lake/river interactions. This presentation will focus on the field methods used to complete this synoptic survey and will provide an in-depth review and analysis of the data. The role of AUVs in the National Monitoring Program in the Great Lakes is unclear; however, such tools can provide valuable information about a system in a fraction of the time it takes a manned boat to complete a survey. *Keywords: Monitoring, AUV, Lake Michigan, Near-shore, Water quality.*

JACOBY, J.B., 3971 Rehbein Rd, Duluth, MN, 55803, United States. **Art & Civic Engagement in Service to Water.**

This presentation will discuss civic engagement techniques focused on water related concerns of Lake Superior. I will discuss research that explored the use of study circles as a means of engaging artists in dialogue about water related concerns. The question driving this research was, "In what ways do study circles empower artists to become community leaders around water issues?" Secondary questions focused on emerging environmental, water, and social justice themes as well as examples of increased water awareness and behavior change occurring as a result of individual participation in the study circles. This research incorporated the use of study circles (also known as dialogue groups, dialogue circles, or talking circles) with artists to learn how study circles empower artists to become community leaders. Literature focusing on civic engagement and the arts has looked at the process of utilizing the arts to engage the public in dialogue about a social concern. This research differs in that it focused on how a dialogue process impacts artists. Key findings conclude that the study circles brought about new methods for problem identification and solving, individual behavior changes, a deeper understanding for others, and the dialogue provided a powerful catalyst for collaboration, leadership and relationship building. *Keywords: Environmental education, Dialogue & art, Lake Superior, Public participation.*

JAHNKE, M., LISDAHL, D., and DANZ, N.P., Department of Natural Sciences, University of Wisconsin-Superior, Superior, WI, 54880. **Research and Restoration on Wisconsin Point Dune Plant Communities by Undergraduates at the University of Wisconsin-Superior.**

Dune plant communities of Wisconsin Point are uncommon and especially sensitive to human disturbance compared to vegetation on more typical red clay substrate along Wisconsin's Lake Superior shore. Yet, Wisconsin Point has high levels of auto and foot traffic from beachgoers and birders alike. In this GLISTEN-funded venture, undergraduates at the University of Wisconsin-Superior are working on two projects related to dune communities and human disturbance on Wisconsin Point. In the first, two stewardship liaisons are evaluating vegetation change by revisiting sites originally surveyed in 1956 by John Curtis during fieldwork for his landmark text 'Vegetation of Wisconsin'. In summer 2010 they surveyed 135 1-m2 quadrats and found a major change over 50 years was the influx of exotic species. In the second project, undergraduates in a general education botany course are working with City of Superior, WI to remove Spotted Knapweed and restore a 4-acre piece of backdune habitat. Absent from Wisconsin Point as recently as 1983, Spotted Knapweed is now the dominant plant in some dune areas. In Fall 2010, students estimated knapweed density >50 plants per m2 and seed production > 10 million seeds per acre in this backdune habitat. Over 200 garbage bags of knapweed were removed by hand-pulling by UWS undergraduates. *Keywords: Invasive species, Dunes, Coastal ecosystems, Plant communities, Restoration.*

JANIK, C.E.[1], CUDNEY, K.A.[1], and PENNUTO, C.M.[2], [1]Biology Department, Buffalo State College, Buffalo, NY; [2]Great Lakes Center, Buffalo State College, Buffalo, NY.
Round Gobies Disrupt Primary Production Dynamics in Lotic Systems.

The invasive round goby occurs in every Great Lake and a large number of tributary streams. Previous work has documented the inland expansion of round gobies and their impacts on benthic fish and invertebrate populations. A round goby-mediated trophic cascade on primary production was examined using a mesocosm experiment coupled with stream observations at sites with and without gobies. Mesocosm treatments differed in fish community composition (n=4) plus 50 snails and 200 amphipods as grazers. Unglazed tiles were used to assess periphyton biomass and chl a in both the mesocosms and the stream. Changes in fish and invertebrate sizes were recorded. Fish showed significant differences in growth over the course of the mesocosm experiment with gobies growing faster than darters ($p<0.001$). A significant treatment difference was seen in both mesocosm algal biomass ($p=0.0019$) and chl a ($p=0.0443$). Periphyton biomass in Ellicott Creek showed significant month ($p<0.001$) and treatment ($p<0.001$) effects, with much greater abundance at the goby-present site. A significant month, but not treatment effect was seen with chl a in Ellicott Creek ($p<0.001$). Although many studies have documented round goby impacts in the Great Lakes, this work documents indirect effects in primary producers resulting from a trophic cascade in streams. *Keywords: Primary Production, Great Lakes basin, Trophic Cascade, Round goby, Algae.*

JENDEREDJIAN, K.[1], HAKOBYAN, S.[2], and STAPANIAN, M.A.[3], [1]Ministry of Nature Protection, Agency of Bioresources Management, Yerevan, 0010, Armenia; [2]2Institute of Hydroecology and Ichthyology, National Academy of Sciences, Yerevan, 0014, Armenia; [3]U.S. Geological Survey, 6100 Columbus Avenue, Sandusky, OH, 44870. **Changes in Benthic Community Biomass and Energy Budgets in Lake Sevan, 1928-2004.**

Water levels of Lake Sevan (Armenia) were artificially lowered by nearly 20 m between 1949 and 1997. Lower water levels, combined with increased eutrophication, were associated with seasonally anoxic conditions near the bottom of the profundal zone during 1976-2004. In addition, the extents of the macrophyte zone and of certain substrate types were severely reduced. Maximal depth of occurrence decreased by 2-44 m for at least for 50 species of benthic macroinvertebrates during 1982-2004 compared to 1937-1961. Species richness of benthic macroinvertebrates declined from 25 to 3 species at depths where seasonal anoxia occurred. Total biomass increased by a factor of 10 from the period 1928-1948 to 1976-1979 then declined by a factor of 3 to 4 between 1987 and 2004. The average ratios of energy flow through detritivores, herbivores, and filter feeders changed from 16.6:2.4:1 during 1928-1971 to 48.5:0.5:1 during 1976-2004. The increase in energy flow through detritivores was associated with increased plankton primary production. The decrease in energy flow through herbivores was associated with reduced areal coverage of macrophytes. These patterns may provide a basis to predict results of restoration efforts as water quality improves. *Keywords: Bioenergetics, Lake Sevan, Biomonitoring, Benthos.*

JENSEN, D.A. and KITSON, M.T., University of Minnesota Sea Grant Program, 131 Chester Park, 31 West College Street, Duluth, MN, 55812-1198. **Science-based Research: A Driver In Aquatic Invasive Species Outreach.**

Effectively interdicting the spread of aquatic invasive species (AIS) in the Great Lakes requires strategic interventions targeting pathways of introduction. Each pathway (e.g., boating, water gardening) can have unique risks for introduction and spread based on activities and products. 'Risky' behaviors based on those activities and products need to change to provide the best protection. AIS outreach can effectively promote behavior change in target audiences by merging advances in social science with up-to-date ecological research. Responding to this need, the Great Lakes Sea Grant Network is leading a GLRI-funded outreach initiative targeting 15 pathways aimed at preventing the spread of AIS. Featuring *Stop Aquatic Hitchhikers!, Nab the Aquatic Invader, Habitattitude, AIS-HACCP* program, and new Web-based social networking components, the effort is employing proven and new strategies to protect the Great Lakes. Driven by survey results and social marketing, new/improved outreach products are being used to reach millions of people. The Great Lakes research community can help extend AIS outreach through your leadership, expertise, and resources. This presentation will discuss approaches and strategies in-use and feature resources that can be adapted or adopted to help protect our waters from aquatic 'hitchhikers'. *Keywords: Public education, Pathways, Outreach, Behavior change, Invasive species.*

JERECZEK, J.C., WAGNER, C., LARSON, N.J., and LEDDER, T.D., Wisconsin DNR, 1701 N 4th Street, Superior, WI, 54880. **Slow the Flow; a Regional Assesment and Managment Srategy for Wisconsin's Lake Shore.**

Most of Wisconsin's Lake Superior south shore tributaries flow through gently sloping topography, heavy red clay soils and short steep sided stream valleys. Changes in the basin's land cover have increased the rate and volume of runoff. Flooding, erosion and sedimentation are identified as the leading cause of basin water quality and habitat impairments. Recent research has demonstrated the link between land-based condition and the health of coastal aquatic ecosystems. Wise land use management of Lake Superior Coastal Watersheds should have positive implications for Lake Superior's near shore ecosystem. Unprotected, the soils in the Basin are unstable, highly erodible and subject to slippage, particularly along streams and lakeshores. Forest management guidance is critical. Research conducted by Sandy Veery, USFS retired, showed that forests 0-15 year age class affect runoff rates in the same way that open land does. In small watersheds with 50-60% open land there is marked increase in runoff rates. The Wisconsin DNR in cooperation with local partners has used this work in the development of a south shore tributary strategy that seeks to "slow the flow." These efforts have led to better forestry practices and improved stream fisheries management.
Keywords: Watersheds, Coastal ecosystems, Hydrologic cycle.

JOHNSON, L.B.[1], BRADY, V.J.[1], BRENEMAN, D.[1], HOST, G.E.[1], NIEMI, G.J.[1], REAVIE, E.[1], DANZ, N.P.[2], and CIBOROWSKI, J.J.[3], [1]Natural Resources Research Institute, University of Minnesota Duluth, Duluth, MN, 55803, USA; [2]University of Wisconsin Superior, Department of Biology, Superior, WI, USA, 54880; [3]Department of Biological Sciences, University of Windsor, Windsor, ON, N9B 3P4, CA. **Quantifying environmental condition in Great Lakes Coastal Areas: A Multi-taxa Approach.**

Despite the incomplete historical data record on Great Lakes habitats, there is consensus that the lakes are rapidly changing. No single indicator can capture the diverse information necessary to evaluate ecosystem condition. A major challenge is to select a subset of many proposed indicators that will effectively and efficiently measure the major components of ecosystem health and can diagnose causes of impaired community function. We have combined the strengths of two common approaches (multimetric and multivariate) to generate derivative, ecologically relevant indicators that have the greatest possible discriminatory power to distinguish degraded systems from least-impaired systems. Using a multi-taxa approach we have examined the behavior of indicators based on fish, invertebrates and diatoms from Great Lakes coastal ecosystem relative to three classes of stressors and 4 classes of habitat variables. The spatial scale of responses for fish varies from that of macroinvertebrates and diatoms. Hydrogeomorphic and ecoregional features seem to exert a much stronger effect on zoobenthos than on fish. Stephanodiscoid diatoms and nest-guarding fish were identified as two of the most promising indicators of row-crop agriculture, particularly at the watershed scale.
Keywords: Ecosystem health, Indicators, Coastal ecosystems.

JOHNSON, T.B.[1], GUZZO, M.[2], and SOPER, K.[3], [1]Ontario Ministry of Natural Resources, Glenora Fisheries Station, Picton, ON, K0K 2T0; [2]Ontario Ministry of Natural Resources, Great Lakes Institute for Environmental Research, Windsor, ON, N9B 3P4; [3]Ontario Ministry of Natural Resources, Lake Erie Fisheries Station, Wheatley, ON, N0P 2P0. **Asian Carp in the Great Lakes: Growth Rate Potential Under Different Prey Regimes.**

Asian carps (*Hypophthalmichthys molitrix* and *H. nobilis*) are poised to invade the Laurentian Great Lakes. Once established, these large bodied and fast growing filter feeding fish are feared to critically deplete plankton resources altering ecological function and threatening the $7 billion Great Lakes fisheries. A recent bioenergetics modelling exercise suggests limited colonisation potential for Asian carp due to limited plankton resources. However, both carp species are opportunistic feeders and will utilise prey much smaller than traditional plankton, including the microbial food web. We use a refined bioenergetics model to explore growth rate potential of Asian carps under different prey regimes to forecast the likelihood of survival, establishment, and spread in the Great Lakes. *Keywords: Invasive species, Bioenergetics, Diets.*

JOHNSON, W.E., KIMBROUGH, K.L., and LAUENSTEIN, G.G., NOAA Mussel Watch Program, 1305 East West Highway, SSMC4/SCI1, 9th Floor, Silver Spring, MD, 20910. **NOAA's Enhanced Great Lakes Mussel Watch Program: Monitoring Contaminant Levels in Mussels and Sediment from Historic Mussel Watch Sites and Areas of Concern (AOC).**

The Mussel Watch Program (MWP) monitors the status and trends of chemical contamination in U.S. coastal waters, including the Great Lakes. MWP is based on yearly analysis of bivalve mollusks that filter water, thus providing an indication of local contamination levels. In addition, sediments are measured on a decadal scale. In the Great Lakes, zebra and quagga mussels (Dreissena sp.) are the sentinel bivalves used for monitoring. In 2009 and 2010 the MWP expanded its program into Areas of Concern (AOCs) in Lakes Erie, Ontario, Huron, Michigan, and Superior. Results will be presented for legacy and contaminants of emerging concern (CECs). Specifically, data will be presented that highlight the magnitude of 2009-2010 levels relative to historic data for the nation. A comparison will also be made between AOCs and ambient MWP sites to characterize the range of concentrations found in this study. *Keywords: Mussels, Chemical analysis, Monitoring.*

JOHNSTON, C.A., Dept. of Biology & Microbiology, South Dakota State University, Brookings, SD, 57007. **Water Chemistry Fingerprints of Coastal Emergent Plant Communities.**

Are emergent plant communities of the U.S. Laurentian Great Lakes coast indicative of nutrients and other chemicals of anthropogenic origin, or are they responding to natural water chemistry gradients? Water chemistry was sampled on all five Great Lakes in 48 wetlands representing 7 plant communities. Nutrients (total N, total P) and chlorophyll a concentrations generally increased in the sequence: poor fens (PF) < bluejoint/tussock sedge marshes (BT) < burreed/lake sedge marshes (BL) < three-square rush marshes (TS) < eastern cattail marshes (EC) < western cattail marshes (WC) < *Phragmites* marshes. Wetland plant communities that occurred mostly on Lake Superior and northern Lake Huron (PF, BT, BL) had lower chloride concentrations than did more southerly wetland communities, consistent with less intensive land use on the northern Great Lakes. Wetland pH was lowest in PF and EC marshes, and highest in TS and WC marshes. Although invasive cattails dominated both EC and WC marshes, WC marshes had significantly greater nitrate, total N, total suspended solids, chlorophyll a, dissolved oxygen, pH, and specific conductance than did EC marshes. These results suggest that Great Lakes wetland chemistry is affected by both natural and anthropogenic sources, and that changes in wetland chemical inputs could shift vegetation types.
Keywords: Wetlands, Water quality, Vegetation.

JOVANOVIC, C.M.[1], FIELDER, D.G.[2], THOMAS, M.V.[3], and SCHAEFFER, J.S.[4], [1]School of Natural Resources, University of Michigan, 440 Church Street, Ann Arbor, MI, 48109; [2]Michigan Department of Natural Resources and Environment, Alpena Fisheries Research Station, 160 E. Fletcher, Alpena, MI, 49707; [3]Michigan Department of Natural Resources and Environment, Lake St. Clair Fisheries Research Station, 33135 South River Road, Harrison Township, MI, 48045; [4]United States Geological Survey, Great Lakes Science Center, 1451 Green Rd, Ann Arbor, MI, 48105. **Population characteristics of a recovering walleye population, Sander vitreus, in Saginaw Bay, Lake Huron.**

Saginaw Bay, Lake Huron, supported a large walleye fishery, but the population crashed by the mid 1940's. Walleye were scarce until the early 1980s, when a fingerling-stocking program began, but natural reproduction was inadequate to sustain the population. Natural reproduction greatly increased beginning in 2003, and stocking was discontinued in 2006. We examined abundance, growth and diet of walleye as they recovered. Abundance increased, but growth began to decline, with large decrease by 2009. Declines in growth were associated with high densities combined with apparent prey limitations; walleyes consumed primarily emerald shiners, round goby, and invertebrates during spring, but switched to age-0 percids by mid summer to the extent that yellow perch recruitment may be limited via high predatory demand. Clupeids were scarce in diets; paradoxically, low clupeid abundance favors walleye recruitment, but abundant clupeids previously promoted fast walleye growth. Maintaining both walleye and yellow perch will likely require rehabilitation of a traditional forage community that included now-extirpated species such as cisco. *Keywords: Walleye, Fish populations, Bioenergetics.*

JUST, A., CORRY, T.D., and HOFFMAN, J.C., US EPA Mid-Continent Ecology Division, 6201 Congdon Blvd, Duluth, MN, 55804. **Zooplankton linkages between rivers and Great Lakes: case study from the St. Louis River.**

In this case study, we characterized the spatial and seasonal distribution and abundance of zooplankton within the hydrologically complex drowned river mouth of the St. Louis River, the second largest tributary to Lake Superior and an important fish nursery. We hypothesize that zooplankton dynamics in Great Lakes river mouth ecosystems are influenced by tributary discharge and periodic seiches. We sampled nine stations along the river-lake transition zone from early May through mid July. The maximum total abundance ranged from 52 zooplankon m^{-3}, which occurred in a protected embayment, to 3.5 zooplankton m^{-3}, which occurred in St. Louis River thalweg samples in the central portion of the study area. Although overall abundance was low in the river, temporal variability was high in upriver samples and low in those stations most influenced by Lake Superior. Species distributions reflected the connection to the lake, with Lake Superior zooplankton most prevalent at the station located adjacent to the lake. Together, zooplankton and water quality data reveal dramatic differences between the lotic river environment and more lentic environments provided by adjacent embayments, which emphasizes the importance of characterizing sub-basins of differing

geomorphology within a river mouth ecosystem. *Keywords: Zooplankton, Tributaries, Coastal wetlands, St. Louis River AOC.*

KAMMIN, L.A.[1] and BOEHME, S.E.[2], [1]1101 W. Peabody Dr., Urbana, IL, 61801; [2]77 W. Jackson Blvd., Chicago, IL, 60604. **Sustainable Unwanted Medicine Collection Programs: Strategies from the Great Lakes States and Beyond.**

Many pharmaceutical chemicals enter the water system when they are excreted, but an unknown quantity also enter the water when people dispose of unused medicines via the trash or toilet. While researchers are beginning to document the effects that discarded medicines have in the environment, the long-term impacts of medicine disposal on human and environmental health are not fully known. Studies have identified a wide range of pharmaceutical chemicals that are harmful to aquatic organisms, affecting reproduction and development even at very low concentrations. Additionally, several pharmaceuticals are now also detected in drinking water supplies. While it is currently thought that the concentrations of these chemicals in drinking water are safe for human consumption, it is worth taking a proactive approach to decrease the amount of unwanted medicines reaching our water supply. The proper disposal of unwanted medicines is a highly complex issue. Communities wishing to host a collection event or program must follow federal, state, and local regulations, which oftentimes contradict one another. This presentation highlights the Illinois-Indiana Sea Grant toolkit "Disposal of Unwanted Medicines: A Resource for Action in Your Community" which provides case studies and discusses legislation and policy that drive this important issue. *Keywords: Water quality, Pollution sources, Public education.*

KANE, D.D.[1], MAVROIDIS, S.M.[1], MAXCY, J.[1], GOLNICK, P.[1], MCKAY, R.M.[2], GRIGGS, N.D.[1], and CZECH, M.[3], [1]Natural Science and Mathematics Division, Defiance College, Defiance, OH, 43512; [2]Department of Biologicial Sciences, Bowling Green State University, Bowling Green, OH, 43403; [3]Department of Biology and Health Sciences, Lourdes College, Sylvania, OH, 43560. **See the Maumee River GLISTEN!.**

As part of the northwest Ohio cluster of the Great Lakes Great Lakes Great Lakes Innovative Stewardship through Education Network (GLISTEN), students and faculty at Defiance College have focused on a number of different activities dealing with the water quality of the Maumee River, the largest tributary/watershed in the Lake Erie basin and in the Laurentian Great Lakes as a whole. The activities have included: water quality monitoring by student liaisons to the Upper Maumee River Partnership, SENCERization (Science Education for New Civic Engagements and Responsibilities) of a variety of courses (ecology, restoration ecology, environment around us, field zoology, and biochemistry II) to include relevant, immediate, community-based issues in the Maumee River watershed (i.e. nutrient and sediment pollution, Harmful Algal Blooms), and outreach to middle school and high school groups. Finally, in this talk we will examine the usefulness of having undergraduate students collect nutrient data for use in research projects by comparing student-obtained results with those obtained from a water quality laboratory. *Keywords: Nutrients, Water quality, Education.*

KANE, D.D.[1], CONROY, J.D.[2], BADE, D.L.[3], EDWARDS, W.J.[4], and CULVER, D.A.[5], [1]Natural Science and Mathematics Division, Defiance College, Defiance, OH, 43512; [2]Division of Wildlife, Ohio Department of Natural Resources, Hebron, OH, 43025; [3]Department of Biological Sciences, Kent State University, Kent, OH, 44242; [4]Department of Biology, Niagara University, Lewiston, NY, 14109; [5]Limnology Laboratory, Department of Evolution, Ecology, and Organismal Biology, The Ohio State University, Columbus, OH, 43212. **Re-Eutrophication of Lake Erie: Multiple Contributions by Two Agricultural Tributaries.**

To gain better insight into watershed effects on lake eutrophication, we evaluate nutrient and phytoplankton dynamics in the Maumee and Sandusky rivers during March-October, 2009-2010. Agriculture dominates the watersheds of these rivers and as such, they have long been recognized as important nutrient sources to Lake Erie. However, we found abundant cyanobacterial communities by March even in first-order tributaries to these rivers, indicating they may serve as a Harmful Algal Bloom sources too. We investigated this role by comparing nutrient dynamics, nutrient limitation metrics, and transport processes at up- and downstream river sites and near- and offshore areas of Lake Erie. We discuss our findings in context of the Algal Loading Hypothesis, which posits that tributary-derived algae, once loaded into Lake Erie, flourish. Finally, our fixed-date sampling in 2009 and storm-event sampling in 2010 permitted us to compare directly the utility of each for properly quantifying tributary nutrient and phytoplankton dynamics. *Keywords: Phytoplankton, Nutrients, Tributaries.*

KANE, D.D.[1], COBURN-GRIFFIS, A.[2], VARGO, R.[2], GORDON, D.[1], KOHLS, A.[1], and LAKES, R.[1], [1]Natural Science and Mathematics Division, Defiance College, Defiance, OH, 43512; [2]Scenic Rivers Program, Ohio Department of Natural Resources, Tiffin, OH, 44883. **Ohio Stream Quality Monitoring Project: Volunteer Monitoring and Undergraduate Research.**

With more than 60,000 miles of streams, Ohio is a water-rich state. Many of Ohio's streams support thriving plant and animal communities, including Ohio's state designated scenic rivers. Administered by the Ohio Division of Watercraft, the Ohio Scenic Rivers Program oversees 14 state designated scenic river systems, comprising 800 river miles along 26 stream segments. These streams represent some of the best of Ohio's waterways. Developed in 1983, the Ohio Stream Quality Monitoring (SQM) Project uses volunteers in aquatic macroinvertebrate monitoring to compile biological and water quality data on the state's scenic rivers. The Ohio SQM Project is an excellent, simple and cost-effective method of assessing a stream's health. To demonstrate the utility of this program, we present data obtained by this volunteer monitoring program that indicates declining water quality in the Maumee River between 1983 and 2008. Further, we will also discuss how the SQM approach has been integrated into senior capstone research projects for undergraduate students. *Keywords: Environmental education, Water quality, Monitoring.*

KAO, Y.[1], ADLERSTEIN, S.A.[1], and RILEY, S.C.[2], [1]440 Church Street, Ann Arbor, MI, 48104; [2]1451 Green Road, Ann Arbor, MI, 48105. **Identifying Causal Links among Recent Changes in the Lake Huron Food Web.**

Many changes resulting from invasive Dreissenid mussels and the predatory cladoceran *Bythotrephes* have been observed in the Lake Huron food web, but causal links among these changes are still unclear. We hypothesized these causal links can be clarified when the sequence of changes is identified. We used generalized linear models to investigate how the abundance of major prey fishes, zooplankton, and benthos changed with time with adjustment for sampling location and season in last 30 years. Results showed many changes occurred abruptly between 2002 and 2004 and coincided with the expansion of the quagga mussel. The abundance of alewife reached a historical low level in 2003 and collapsed after 2004. Non-predatory cladocerans (mainly *Bosmina* and *Daphnia* but excluding *Holopedium*) decreased sharply in 2003 and have not recovered. The abundance of benthic amphipod *Diporeia* declined steadily until 2003 but dropped significantly after 2004. However, *Bythotrephes* maintained a high abundance through the study period. We conclude that the collapse of the alewife population is unlikely driven by the decline of *Diporeia*, but the collapse of alewife made *Bythotrephes* more aggressive and may be the cause of the reduction in major zooplankton groups. *Keywords: Invasive species, Food web, Lake Huron.*

KAPUSCINSKI, K.L.[1], FARRELL, J.M.[1], and WILKINSON, M.A.[2], [1]State University of New York, College of Environmental Science and Forestry, 1 Forestry Drive, Syracuse, NY, 13210; [2]New York State Department of Environmental Conservation, 270 Michigan Avenue, Buffalo, NY, 14203. **Trends in the muskellunge (Esox masquinongy) population and fishery of the Buffalo Harbor (Lake Erie) and upper Niagara River.**

We review the history of muskellunge management and describe population and fishery trends. Stocking occurred sporadically in the Niagara River in 1941-1974, when angler harvest was common. Since the late 1970s, managers have enacted increasingly restrictive minimum length limits and anglers have adopted a catch-and-release ethic. Despite these efforts, angler catch rates declined sharply from the mid-1990s to the early 2000s; catch rates have since rebounded in the Niagara River, but remain at all-time lows in the Buffalo Harbor. Managers now focus on monitoring young-of-year (YOY) production and identifying, protecting, and restoring critical habitats. Seining surveys show YOY muskellunge production in 2007-2010 was highly variable among sites (within years) and years, but catch per unit effort was 5.5 times higher at Niagara River sites than Buffalo Harbor sites. Mean catch rates of YOY in fall electrofishing surveys declined from 8.2/hr in 1992-1993 to 1.7/hr in 2006-2009 in the Buffalo Harbor and 11.0/hr in 1992-1994 to 5.4/hr in 2006-2009 in the Niagara River. Studies of YOY diets and fish assemblages suggest suboptimal habitat and prey are leading to poor production at some sites, especially in the Buffalo Harbor. Other potential limitations to recruitment are discussed, as is the need for a formal management strategy. *Keywords: Fish management, Muskellunge, Niagara River, Fisheries.*

KAPUSCINSKI, K.L.[1], FARRELL, J.M.[1], and WILKINSON, M.A.[2], [1]State University of New York, College of Environmental Science and Forestry, 1 Forestry Drive, Syracuse, NY, 13210; [2]New York State Department of Environmental Conservation, 270 Michigan Avenue, Buffalo, NY, 14203. **Feeding ecology and population structure of a non-native cyprinid, the rudd (Scardinius erythrophthalmus), in the Buffalo Harbor (Lake Erie) and upper Niagara River.**

The invasive European rudd was the most abundant fish in spring trap-net catches in the Buffalo Harbor and Niagara River in 2007-2008 (49% of total catch), causing concern about their potential effects on the ecosystem. We conducted a study in 2009 to examine rudd feeding ecology, condition, and growth, and used data from 2007-2010 standardized seining surveys to quantify their reproductive success. Rudd were mostly herbivorous, they consumed aquatic macrophytes in summer and supplemented their diet with algae and fish during spring and fall. Feeding intensity was positively correlated with water temperature, but significantly reduced during spawning. Rudd condition and growth were greater than available estimates from other populations, suggesting increases in abundance and range expansion are possible. Furthermore, reproduction was successful at lotic sites, whereas no young-of-the-year rudd were captured at lentic sites. The paradigm of optimal rudd habitat and water bodies vulnerable to invasion should be expanded to include lotic waters. The rudd possesses several traits that make it a successful invader, including the ability to consume macrophytes that are underutilized by native north temperate freshwater fishes in North America. Research is needed to understand how herbivory by rudd affects native aquatic communities. *Keywords: Exotic species, Rudd, Biological invasions, Diets.*

KARATAYEV, A.E.[1], MASTITSKY, S.E.[2], BURLAKOVA, L.E.[1], KARATAYEV, V.A.[3], CONN, D.B.[4], and HAJDUK, M.M.[5], [1]Great Lakes Center, Buffalo State College, Buffalo, NY, 14222; [2]Department of Theoretical Bioinformatics, German Cancer Research Center, Heidelberg, 69120, Germany; [3]University Honors College, State University of New York at Buffalo, Buffalo, NY, 14260; [4]Office of International Health and Biodefense, U.S. Department of State, Washington, DC, 20520; [5]Department of Biology, Buffalo State College, Buffalo, NY, 14222. **Exotic Mollusks in the Great Lakes Region Host Pathogenic Trematodes.**

During 2009 - 2010 seven species of exotic molluscs were examined for the presence of trematodes, including *Dreissena polymorpha, D. rostriformis bugensis, Bithynia tentaculata, Valvata piscinalis, Corbicula fluminea, Cipangopaludina chinensis*, and *Potamopyrgus antipodarum*. Most of the exotic molluscs were infected with trematode larvae that may be harmful for their subsequent vertebrate hosts. These included *Sphaeridiotrema globulus* cercariae and *Cyathocotyle bushensis* metacercariae from *B. tentaculata*, which as adults may cause severe ulcerative enteritis in waterfowl. Also included were *Echinostoma* sp. cercariae from *V. piscinalis* and echinostomatid metacercariae from *Dreissena* spp. and *C. fluminea*, which as adults may cause severe enteritis in birds and mammals, including humans in some species. Many exotic molluscs that were believed to be free of parasites have already acquired trematodes native to North America, other exotic molluscs hosted exotic trematodes, including those highly pathogenic to their vertebrate hosts. In 6 out of 12 waterbodies studied exotic molluscs had high enough prevalence of trematode infection to pose medium to high risk of parasites transmission to their subsequent vertebrate hosts. *Keywords: Great Lakes basin, Trematoda, Mollusks, Parasites, Exotic species.*

KARATAYEV, V.A.[1], KARATAYEV, A.Y.[2], and BURLAKOVA, L.E.[2], [1]University Honors College, State University of New York at Buffalo, Buffalo, NY, 14260; [2]Great Lakes Center, Buffalo State College, Buffalo, NY, 14222. **Lakewide Dominance Does Not Predict the Invader Species for Dreissenids.**

In recent years, quagga mussels (*Dreissena rostriformis bugensis*) have almost completely replaced zebra mussels (*D. polymorpha*) in the lower Great Lakes. As recreational boats are the main vector of dreissenid spread in North America, this study examined whether lakes Erie and Ontario still could be a source of zebra mussels' secondary spread. In the summer-fall of 2010, 208 boats from 5 marinas and 41 littoral substrates on lakes Erie and Ontario were examined. A total of 98 boats (47%) were fouled by *Dreissena*, including 84 fouled by both species, 12 by zebra mussels only, and 2 by quagga mussels only. Although quagga mussels comprise over 99% of dreissenids in eastern Lake Erie and in Lake Ontario, the zebra mussel was often dominant on boats and attained significantly larger sizes. The relative abundance of the zebra mussel on boats was also significantly higher than on temporary substrates (floating docks). Refuges of zebra mussels in lakes include shallow areas with high wave activity and tributaries. Lower Great Lakes still remain a source for the secondary spread of zebra mussels.
Keywords: Biological invasions, Spread, Dreissena, Vector, Great Lakes basin.

KELLY, J.R. and YURISTA, P.M., U.S. Environmental Protection Agency, Mid-Continent Ecology Division, Duluth, MN, 55804, USA. **An Integrated Set of Observations to Link Conditions of Great Lakes Nearshore Waters to Their Coastal Watersheds.**

We combine three elements for a comprehensive characterization that links nearshore conditions with coastal watershed disturbance metrics. The three elements are: 1) a shore-parallel, high-resolution nearshore survey using continuous in situ towed sensors; 2) a spatially-balanced, random probability survey of nearshore stations; and 3) characterization of contributing watersheds using metrics developed in the Great Lakes Environmental Indicators (GLEI) project. We completed 6000 km of high-resolution nearshore tows (virtually all the US coastline) in surveys from 2004 to 2010. We use a

random probability survey piloted in Lake Erie to develop the example of how the three elements work in concert as an observing system. Nearshore station-based TP concentrations were modeled [N = 45, R2 = 0.74] as a function of three independent variables: (a) water column depth, (b) an agricultural landscape metric (non-point source), and (c) a point source landscape metric. Predictions from models such as this compare favorably with the observations from the continuous sampling, in which alongshore patchiness and "banding" of conditions appears coincident with patterns of alongshore landscape variability. The approach provides strong insights about nearshore response to landscape stressors across scales from localized to region-wide.
Keywords: Coastal ecosystems, Watersheds, Observing systems.

KENDALL, S.T.[1], BIDDANDA, B.A.[1], and NIEBERDING, P.[2], [1]GVSU Annis Water Resources Institute, 740 W. Shoreline Drive, Muskegon, MI, 49444; [2]Fondriest Environmental, Inc., 1415 Research Park Drive, Beavercreek, OH, 45432. **A New Moored Buoy Observatory in the Muskegon Lake AOC (Muskegon, MI).**

A buoy observatory is being established for Muskegon Lake in the proximity of 43.23824 lat. and 86.28052 long. corresponding to 14 m water depth. Muskegon Lake is a drowned river mouth lake and an Area of Concern due to a long history of anthropogenic stress. Primary goals for the buoy system are to monitor the lake ecosystem with a focus on algae, cyanobacteria, inorganic/organic nutrients (nitrates, CDOM, DO), suspended sediments, and hydrodynamics. The system will consist of a 5 ft. dia. surface buoy, subsurface buoy, and suspended and lake floor sensors; a design for immediate needs yet flexible for deployments in the Great Lakes or shallower areas. The subsurface buoy will support suspended sensors at multiple depths and allow easier retrieval for servicing. The surface buoy will be tethered to the subsurface buoy and is equipped with the master data logger, batteries, solar panels, and a met station. A bottom-mounted acoustic Doppler profiler, tethered to the surface buoy, will provide insights into ecosystem responses to wind forces, current velocity, residence time, suspended sediment plumes, and, potentially, diel movement of zooplankton. The observatory data will be linked to other observation networks, and complement an ongoing discreet sampling and analysis program conducted since 2006. *Keywords: Biomonitoring, Data acquisition, Measuring instruments.*

KENNEDY, G.W.[1], BOASE, J.C.[2], CRAIG, J.M.[1], and ROSEMAN, E.F.[1], [1]US Geological Survey - Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105; [2]U.S. Fish and Wildlife Service, Alpena FWCO - Waterford Substation, 7806 Gale Rd., Waterford, MI, 48327. **Adaptation of Two Techniques for Sampling Fish Eggs and Larvae in Deep Rivers.**

Sampling for fish eggs and larvae in large river systems like the Detroit and St. Clair Rivers presents many challenges and obstacles. Methods for sampling benthic eggs and larval drift were adapted to resolve field sampling problems common to these complex rivers. As part of habitat remediation efforts we evaluated the extent of fish spawning using egg mats. Buoys used to mark gear were often lost to boat traffic, excessive plant/debris drift, and vandalism. To resolve these issues, we developed a buoy-less deployment and retrieval method using submersed poly line and GPS. Retrieval was accomplished using a grapnel to hook the poly line. Our study also assessed drift of larval lake sturgeon from known spawning reefs using D-frame style nets. Our reef sites (>8m deep) were inaccessible using standard deployment methods, so nets were deployed using a triple-point bridle attached to the net, then attached to an anchor deployed upstream of the reef using a 33 m braided nylon rope. A buoy was attached to the net and used to drop and lift the net during sampling. Our adaptation of the egg mat and D-frame net technique for sampling eggs and larval lake sturgeon were simple to assemble on the boat, was quickly deployed, and could be easily and safely tended from the vessel repeatedly throughout the sampling period with minimal loss. *Keywords: Great Lakes basin, Sampling methodology, Bottom sampling, Data acquisition.*

KERFOOT, W.C.[1], YOUSEF, F.[1], GREEN, S.A.[2], SCHWAB, D.J.[3], and VANDERPLOEG, H.A.[3], [1]Lake Superior Ecosystem Research Center and Department of Biological Sciences, Michigan Technological University, Houghton, MI, 49931-1295; [2]Department of Chemistry, Michigan Technological University, Houghton, MI, 49931-1295; [3]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48108-9719. **Approaching Storm: Update on Disappearing Chl a in Lake Michigan and Food Web Responses.**

Late winter phytoplankton blooms are common in the lower (southern Lake Michigan, Saginaw Bay and southern Lake Huron, Lake Erie), providing resources for over-wintering plankton. However, the winter blooms are now exploited by veliger larvae from the introduced, cold-water adapted "profunda" morph of quagga mussels (*Dreissenia rostriformis bugensis*). Remote sensing and ship studies reveal that settled adult mussels are causing an extraordinary increase in water transparency and a simultaneous decrease in Chl a in late winter and early spring waters. Before quagga mussels in 2001, water transparency varied between 74-85% at deep-water sites, whereas it increased progressively to 89% by 2006 and 94-96% by 2008. Chlorophyll *a* concentrations ranged between 1.1-2.6 μg/L and 1.8-2.6 μg/L in the western and eastern "doughnut" rings, declining to 0.5-1.7 μg/L by 2006 and 0.4-1.5 μg/L by 2008. Reductions of Chl a between 2001 and 2008 were 56-78% in the western limb, 74-75% in the eastern limb, and 53% for the entire basin (2000-2010). Zooplankton species composition and abundance has changed, as cyclopoid copepods have become scarce, whereas predatory *Bythotrephes* have increased as alewives have declined. Reduction in late-winter phytoplankton poses a serious threat to open-water food webs.
Keywords: Invasive species, Lake Michigan, Remote sensing, Quagga mussels, Productivity, Zooplankton.

KIRETA, A.R.[1], REAVIE, E.D.[1], ALLINGER, L.E.[1], and CHRAIBI, V.L.S.[2], [1]Natural Resources Research Institute, University of Minnesota Duluth, Ely, MN, 55731; [2]Water Resources Science, University of Minnesota Duluth, Duluth, MN, 55812. **Lake Superior ecological history and current trajectory as told by diatoms.**

Considered the most pristine of the Great Lakes, Lake Superior has nevertheless endured human disturbances. We summarize historical findings based on decades of algal plankton assessments, open water monitoring surveys and paleolimnological studies. These efforts reveal that Lake Superior has experienced increasing then decreasing nutrient stress (corresponding with the Clean Water Act of 1972), followed by sharp declines of primary productivity, increased water temperatures, decreased ice cover and recently increasing ion concentrations. Most recently, algal abundances are the lowest ever recorded and may indicate factors other than nutrients, such as climate variables, are influencing primary productivity. These recent trends are puzzling, so a new paleolimnological study has been initiated to examine modern conditions in a long-term context and to reaffirm Lake Superior's natural and post-European settlement condition. Diatoms from sediment cores are being analyzed to fill the 30-year gap since previous sedimentary analysis, and diatom-inferred ecological data will be related to water quality, land use and concurrent monitoring results. We aim to understand natural variability, clarify historical changes and identify past and potential anthropogenic disturbances in Lake Superior. *Keywords: Environmental effects, Paleolimnology, Lake Superior.*

KITCHELL, J.F.[1], CLINE, T.J.[1], BENNINGTON, V.[2], and MCKINLEY, G.A.[2], [1]Center for Limnology, University of Wisconsin-Madison, Madison, WI, 53706; [2]Atmospheric & Oceanic Studies, University of Wisconsin-Madison, Madison, WI, 53706. **Sea lamprey in Lake Superior: Responses to increased host abundance and climate change.**

The establishment of exotic sea lamprey in Lake Superior drove many economically and ecologically important native fish populations to low abundances. During the period of 1960-80, through successful management and treatment, adult sea lamprey populations were reduced to less than 10% of their former abundance and native fish populations have increased several-fold. Native lake trout are a preferred host of lamprey and as trout populations increased, sizes of adult sea lamprey increased. Since 1980, sizes of adult sea lamprey have continued to increase in spite of stabilizing lake trout populations. This increase corresponds with a general rise in average lake temperatures, which owes to climate change effects. Lake Superior is now the most rapidly warming lake on the planet. Larger lampreys kill more host fishes and have higher fecundity. This talk addresses lake wide changes to sea lamprey in Lake Superior due to host availability and increasing water temperatures as well as spatial variation in size and consumption. It also takes an adaptive management approach to the challenges for future lamprey control based on regional differences in lake warming effects proximate to rivers and streams where larger lampreys spawn. *Keywords: Spatial distribution, Adaptive management, Lake trout, Sea lamprey, Lake Superior, Climate change.*

KITSON, M.T.[1], SEITZ, B.[2], and JENSEN, D.A.[1], [1]University of Minnesota Sea Grant Program, 134 Chester Park, 31 West College Street, Duluth, MN, 55812-1198; [2]Grand Portage National Monument, 170 Mile Creek Road, PO Box 426, Grand Portage, MN, 55605. **Moving Beyond the Borders: National Park Service Forms Partnerships for Preventing the Spread of Aquatic Invasive Species.**

Outreach and education forms the information conduit between the general public and academic research. Application of sound research from both biological and social sciences can be powerful in combination when anthropogenic activity is implicated in negative impacts on our environment. Such is the case with aquatic invasive species (AIS). Research supports a human-mediated transport vector hypothesis for AIS, and this information must be made accessible to water recreationists to break this vector. Creative partnering between Grand Portage National Monument and Minnesota Sea Grant is increasing capacity for AIS outreach to historically underserved audiences and has intensified outreach efforts along the North Shore of Lake Superior. Through this partnership, outreach capacity increased by approximately 50%. As an outgrowth of this collaboration, several other outreach opportunities arose. Between August and December 2010, over 2,700 contacts were made and over 3,500 educational materials were distributed between Duluth and Grand Portage, MN. Preliminary survey results indicate 37% of people reached felt their AIS awareness increased a large amount after attending an AIS presentation. Additionally, 59% (a 29% increase) reported they would always take action to prevent the spread of AIS. *Keywords: Outreach, Partnering, Invasive species, Social science, Education, Biological science.*

KLING, H.[1], WATSON, S.B.[2], SALKI, A.[3], MCCULLOUGH, G.[4], and STAINTON, M.[5], [1]Algal Taxonomy and Ecology Inc, 31 Laval Dr, Winnipeg, MB, R3T2X8, Canada; [2]2NWRI, Water Science and Technology Directorate, Environment Canada, Burlington, ON, L7R 4A6, Canada; [3]Salki Consultants, Winnipeg, MB, R3T4K5, Canada; [4]Centre for Earth Observations Sciences, Department of Geography and Environmental Studies, University of Manitoba, Winnipeg, MB, R3T2N2, Canada; [5]5Chemistry Department, Fisheries and Oceans Canada, Freshwater Institute, Winnipeg, MB, R3T2N6, Canada.
Long Term Changes in Lake Winnipeg and Lake of the Woods Plankton.

Plankton assemblages have changed considerably in Lake Winnipeg and Lake of the Woods over the past 100 years , especially since the 1990's. Core data as well as historic and recent documentation suggest shifts in some dominant taxa, as well as increased abundance. Exotic species are also now prevalent in both lakes. This presentation will discuss some of the shifts in the communities over the past century and relate this to water quality and basin characteristics. *Keywords: Biological invasions, Lake of the Woods, Water quality, Phytoplankton, Lake Winnipeg, Zooplankton.*

KLUMP, J.V.[1], ANDERSON, P.D.[1], WECKERLY, K.[1], SZMANIA, D.C.[1], WAPLES, J.T.[1], TOMZIK, E.[2], VALENTA, T.J.[3], and KENNEDY, J.A.[3], [1]Great Lakes WATER Institute, University of Wisconsin-Milwaukee, Milwaukee, WI, 53204; [2]Carrol College, Waukesha, WI; [3]Green Bay Metropolitan Sewerage District, Green Bay, WI.
Observations of hypoxia and linkages to climatic changes in biogeochemical cycles in Green Bay, Lake Michigan.

Green Bay, Lake Michigan has a history of hyper-eutrophic conditions dating back nearly a century. Nutrient inputs from the Fox River in the southern end of the bay represent approximately one-third of the total nutrient loading to the Lake Michigan basin as a whole. The bay itself acts as an efficient particle trap accumulating organic rich sediments that quickly become anaerobic. Summertime sediment oxygen demand is both relatively high (ranging up to 2 mmol m^{-2} h^{-1}) and fairly wide-spread. Consequently, seasonal hypoxia is a recurring phenomenon in late summer. Because the bay is relatively shallow, mixing and stratification play a major role in the onset and duration of hypoxic events. Future climate scenarios project warmer and wetter conditions with shorter winters, increased winter runoff, increased frequency of heavy rainfall events, and an extended stratified period, all of which can impact hypoxia. Climate change may also trigger indirect consequences. A systematic southerly shift in the prevailing summer storm track in the Great Lakes region has altered circulation and mixing patterns in the Green Bay resulting in an increase in the efficiency with which materials are trapped within the bay, and warmer bottom waters. *Keywords: Green Bay, Hypoxia, Eutrophication, Climate change.*

KLUMP, J.V. and EDGINGTON, D.N., Great Lakes WATER Institute, University of Wisconsin-Milwaukee, Milwaukee, WI, 53204. **Diagenesis of Sedimentary Organic Carbon in Lake Baikal.**

Lake Baikal is the largest, oldest and deepest lake in the world. Sediment cores collected from water depths ranging from 100 m to 1710 m in the deepest basin of the lake have been analyzed for pore water chemistry, organic C and N content, and C and N stable isotope abundances. Kinetic models of organic matter decomposition predict first order decomposition rate constants which range from 0.0009 to 0.022 yr^{-1}. The calculated residence times for the metabolizable organic matter in these sediments increases roughly with increasing water depth and is on the order of 50 to 300 years. Similar to what has been shown in marine sediments, the relationship between mass sediment accumulation rates and the modeled decomposition rate constants is essentially linear with a slope of ~1. This relationship has the potential for estimating sedimentation rates throughout the lake based upon modeling organic carbon diagenesis. Comparison with the shallower Laurentian Great Lakes demonstrates that sedimentary organic matter diagenesis in freshwater sediments in large lakes show consistent correlations with water depth and carbon deposition among a variety of parameters (e.g. apparent initial age at deposition, residence time of metabolizable material, turnover rate, C:N stoichiometry, carbon burial and preservation). *Keywords: Carbon, Lake Baikal, Sediments, Diagenesis.*

KOCOVSKY, P.M.[1] and CHAPMAN, D.[2], [1]Lake Erie Biological Station, 6100 Columbus Ave, Sandusky, OH, 44870; [2]Columbia Environmental Research Center, 4200 New Haven Road, Columbia, MO, 65201. **Suitability of the Maumee River for Spawning of Silver and Bighead Carp.**

Silver carp (SC) and bighead carp (BC) invaded the Mississippi in the 1970s and spread to the Chicago Sanitary and Shipping Canal (CSSC) and the Wabash River. Both are connected to the Great Lakes via interconnected waterways. Whether SC and BC establish self-sustaining populations after entering the Great Lakes depends in part on availability of suitable spawning habitat. We examined thermal suitability of the western basin of Lake Erie and hydrographic suitability of the Maumee River for spawning of SC and BC for the years 1990-2009 based on spawning requirements in the Russian and Chinese literature using municipal water intake data and US Geological Survey flow data. Both species typically spawn on rising limbs of hydrographs. Eggs drift during incubation, which lasts for 1-2 d depending on water temperature. Pelagic fry consume primarily phytoplankton and small zooplankton typically in floodplain environments or backwaters. Temperatures in the western basin were sufficiently warm to ensure rapid growth and maturation of SC and BC all years. At least one flood event occurred in most years after thermal thresholds for spawning were reached. Plankton-rich waters of Maumee Bay provide suitable rearing habitat for fry. Based on available information, the Maumee River is likely suitable habitat for mass spawning of SC and BC.
Keywords: Invasive species, Lake Erie, Fish.

KOHLHEPP, G.W., Michigan Constitution Hall, 2nd Floor South, 525 West Allegan Street, Lansing, MI, 48909. **Lake Michigan Tributary and Nearshore Water Quality Monitoring In Michigan.**

The Michigan Department of Environmental Quality conducts extensive water quality monitoring in Lake Michigan tributaries and nearshore areas. Since 2000, the MDEQ, in partnership with the U.S. Geological Survey, has collected water grab samples each year near the mouths of 11 Lake Michigan tributaries. Samples are analyzed for a suite of nutrients, ions, and trace metals (including mercury). Flow information is recorded, and the resulting data are used to evaluate long-term trends and to estimate constituent loads to Lake Michigan. The MDEQ recently received a Great Lakes Restoration Initiative grant to augment the tributary sampling project, by increasing the number of grab samples and also utilizing automated samplers in six rivers to collect samples during high-flow events. Additional Lake Michigan nearshore monitoring activities supported by the MDEQ include fish and wildlife contaminants, beaches, water sampling in Grand Traverse Bay, and participation in the 2010 National Coastal Condition Assessment (which included 107 sites in Michigan nearshore waters of Lake Michigan). This presentation will include a description of these activities, selected results, and a discussion of how these projects are integrated with other nearshore Lake Michigan monitoring and research efforts. *Keywords: Environmental contaminants, Lake Michigan, Water quality.*

KONDABOLU, S. and LENTERS, J.D., School of Natural Resources, University of Nebraska-Lincoln, Lincoln, NE, 68583. **Changes in the seasonal water balance of the Tahquamenon River watershed since 1953: Earlier spring onset in the northern Great Lakes region.**

Research over several decades has shown that climate change is impacting water resources worldwide, with snow-dominated watersheds generally exhibiting a trend toward earlier spring runoff. The Great Lakes, which hold over 20% of the world's available fresh water, have been experiencing changes in seasonal lake levels that suggest a similar trend towards earlier spring freshet within the Great Lakes watershed. In the present study, we investigate these trends by performing a detailed analysis of the water balance of a specific, snow-dominated watershed within the eastern Lake Superior basin. Daily and monthly streamflow data for the Tahquamenon River (in northern Michigan) are examined from 1953-2010 and are compared to measurements of precipitation and temperature over the same time period. A time series analysis of the streamflow's annual center-of-mass date (CMD) is also performed to quantify long-term changes in the timing of spring snowmelt. Results of the monthly analysis show significant increasing trends in streamflow during January, February, and March, followed by downward trends during May, June, July, and September. This is consistent with the temperature and CMD analysis, which show significant winter and springtime warming and an advance in the spring freshet of approximately two weeks over the 58-year period.
Keywords: Hydrologic budget, Watersheds, Climate change.

KOONCE, J.F.[1], BERGQUIST, G.[1], DOROBEK, A.C.[1], and MACK, J.[2], [1]Department of Biology, Case Western Reserve University, Cleveland, OH, 44106-7080; [2]Cleveland Metroparks, Natural Resources Division, Cleveland, OH, 44144. **Civic Engagement of Students through Analysis of Effects of Urbanization on Watershed Processes.**

Degradation of wetlands through excessive runoff associated with urbanized landscapes is an important issue confronting management of natural ecosystems of the Cleveland Metroparks. The presentation reviews the results of a test of a civic engagement, inquiry-based pedagogy to introduce students to the application of quantitative skills to problem solving and to the translation of findings to natural resource managers and members of the general public. The test transformed a long-standing quantitative biology laboratory in which students learned programming and data analysis skills through a series of set problems and datasets into an open inquiry-based lab focused on data analysis and modeling in support of an ecosystem management plan for the natural resources of the Lake-to-Lake Trail, which is a recently acquired wetland complex in the Big Creek Reservation of Cleveland Metroparks. Through analysis of various measures of student learning gains and of student evaluations, we compare skill development and quality of data analysis with previously versions of the course. We also report evaluations of the effect of the need for communication of analysis results to

managers and to the general public on learning gains and motivation.
Keywords: Education, Watersheds, Wetlands.

KORYTNY, L.M., Ulan-Batorskaya 1, Irkutsk, 664033, Russian Federation.
Anthropogenic Impacts on Baikal's Biota.

Presented are the results derived from investigating Baikal, the deepest lake on the globe. The main impacts on the lake and on organisms inhabiting it are considered: the lake's water table changes as the consequences of the construction of the dam for the Irkutsk hydroelectric power station across the Angara river flowing from the lake; contamination and pollution of the lake by wastewaters from ships, residential centers and enterprises, and the aftermaths of tourism. Particular attention is given to the negative influence of the discharges from the Baikalsk pulp-and-paper mill. A hydrological regionalization of Baikal's shore area has been carried out (5 okrugs, and 13 districts), and the priorities of anthropogenic impacts identified. The largest extensive impact is associated with the lake's water level rise that occurred 50 years ago due to the construction of the hydroelectric power station on the Angara. In general, Baikal has persisted in good condition, no reliable changes in the populations living in the lake have been revealed, and pollution has a local, temporal character. However, a number of challenging problems are to be promptly coped with; specifically it is necessary to shut down or convert the Baikalsk mill. *Keywords: Hydrologic budget, Lake Baikal, Economic impact, Water table, Pollution sources.*

KOWALSKI, K.P., CARLSON-MAZUR, M.L., DOTY, S., HOYT, S., and MOLENHOUSE, J., USGS - Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105. **Coastal Wetland Ecosystem Rehabilitation Through Hydrologic Reconnection: Diked Wetlands in Western Lake Erie.**

Great Lakes coastal wetlands provide vital habitat to fishes and a suite of other biota, however, the condition of and access to coastal wetlands have declined significantly. Fish, invertebrates, birds, plants, and water quality in the Crane Creek coastal and diked wetland complex (Lake Erie) were sampled quantitatively to characterize spatial and seasonal patterns and prepare for habitat rehabilitation associated with hydrologically reconnecting diked wetlands to Lake Erie. Great Lakes Restoration Initiative funding supported construction of a water-control structure that restored a hydrologic connection between a diked wetland and Lake Erie, thus allowing full access by fishes and variability in wetland hydrology. The intensive sampling revealed pronounced differences in hydrology, water quality, and fish assemblages between the Crane Creek coastal wetlands, the wetland to be restored, and a reference wetland. Data suggest that maintaining a long-term hydrologic connection between diked and coastal wetlands in Lake Erie will allow fishes to use vegetated habitats regularly and other wetland functions to be restored. Periodic management actions involving hydrologic isolation of the diked wetlands could be used to mimic intermediate levels of disturbance and maintain wetland vegetation. *Keywords: Coastal wetlands, Habitats, Lake Erie.*

KRAEMER, B.M.[1], MCINTYRE, P.B.[1], HUTTULA, T.[8], KOTILAINEN, P.[10], O'REILLY, C.B.[2], PELTONEN, A.[9], PLISNIER, P.D.[3], SARVALA, J.[4], VADEBONCOEUR, Y.[5], VERBURG, P.[6], and WEHRLI, B.[7], [1]Center for Limnology, University of Wisconsin, Madison, WI; [2]Biology Department, Bard College, New York City, NY; [3]Department of Biology, Royal Museum for Central Africa, Namur, Belgium; [4]Department of Biology, University of Turku, Turku, Finland; [5]Department of Biology, Wright State University, Dayton, OH; [6]National Institute of Water and Atmospheric Research, Hamilton, New Zealand; [7]Department of Aquatic Chemistry, Eawag, Zurich, Switzerland; [8]Finnish Environment Institute, Freshwater Centre, Modelling and Assesment Unit, Jyväskylä, Finland; [9]Regional Economic, Traffic and Environment Centre of Pirkanmaa, Tampere, Finland; [10]Finnish Environment Institute, Helsinki, Finland. **Pelagic and Littoral Warming in Lake Tanganyika, East Africa.**

Large lakes across the globe are experiencing increased temperatures, demonstrating their susceptibility to climate change despite their volume and thermal inertia. These temperature increases can have radiating impacts on biodiversity and ecosystem dynamics. Less is known about the impact of warming on Lake Tanganyika's littoral ecosystems, which support globally-significant levels of endemic species. We will summarize long term records of pelagic temperature profiles, and present recent near-shore temperature data that demonstrate the importance of water temperature for littoral ecosystem dynamics. These long-term datasets highlight the need to monitor lake temperature in both pelagic and littoral zones to improve our understanding of climate change impacts on large lakes. *Keywords: Africa, Littoral zone, Ecosystems.*

KRAKAUER, N.Y., Department of Civil Engineering, The City College of New York, New York, NY, 10031. **Seasonal Forecasting in the Great Lakes Region: Assessing Uncertainty.**

Predictability on seasonal timescales can be useful for climate-sensitive sectors such as agriculture and water management, provided their uncertainty is described to users fully and realistically. Current seasonal forecast operational products, with statistical associations based on sea-surface temperature patterns such as ENSO, have limited skill over the Great Lakes region. However, warm-season forecast skill can be improved by also considering antecedent land-surface state (e.g. Drought Stress Index) as a predictor. I will quantify the improvement in forecast skill offered by land surface information using the joint histogram of the predictor and response variables, and use the joint histogram to describe forecast uncertainty and show how it reflects nonlinearities in the climate system. *Keywords: Climate change, Seasonal forecasting, Hydrologic cycle, Predictability, Water level fluctuations, Bayesian statistics.*

KRUGER, B.R., MINOR, E.C., WERNE, J.P., and JOHNSON, T.C., Large Lakes Observatory, University of Minnesota, Duluth, Duluth, MN, 55812. **Spatial Distribution and Sources of Sedimentary Carbon in Lake Malawi, Africa.**

Currently, the source of organic matter to Lake Malawi (Africa) surface sediments is unclear; studies of offshore north-basin cores (363 m to 403 m water depth) have produced conflicting results regarding the proportion of aquatic versus terrestrial organic carbon (OC) contained in these sediments. To address this question, ten multi-cores were recovered from the north basin of Lake Malawi along a transect that follows a major river delta into the lake's deep basin (82 m to 386 m water depth). Initial bulk surface sediment data indicate that while the C/N ratio of organic matter decreases with distance from shore (ranging from 9.8 to 8.3, $R^2 = 0.58$), and stable carbon isotope values become increasingly ^{13}C-depleted (ranging from -21.65 to -25.25, $R^2 = 0.80$), the concentration of OC (wt %) generally increases (ranging from 1.9% to 4.5%, $R^2 = 0.77$). These combine trends suggest substantial carbon contribution from aquatic sources, particularly in the deeper-water, open-lake sites. Downcore, C/N ratios decrease in all cores, suggesting preferential preservation of organic carbon relative to organic nitrogen throughout the lake. *Keywords: Africa, Organic carbon, Sediments.*

KUTOVAYA, O.A., BULLERJAHN, G.S., and MCKAY, R.M., Department of Biological Sciences, 217 Life Sciences Building, Bowling Green, OH, 43402, US.
Expression Of Phosphorus Assimilation Genes In Endemic *Synechococcus* Of The Laurentian Great Lakes.

We are examining the genetic potential of picocyanobacteria to recruit different sources of organic phosphorus in both Lake Erie and Lake Superior. The pelagic regions of Lake Superior and eastern Lake Erie are typically P-limited environments, and picocyanobacteria of the genus *Synechococcus* are the dominant primary producers during the summer. Specifically, we are examining the ability of endemic microbes to assimilate organic phosphates and phosphonates. As a proxy for their utilization of these substrates, we are monitoring the expression of two genes, *phnD* and *phoX*. The *phnD* gene encodes the phosphonate binding protein of the ABC-type phosphonate transporter, whereas the *phoX* gene encodes a calcium-dependent alkaline phosphatase. We have developed PCR primers to detect the presence of both genes in the endemic picocyanobacteria, and RT-PCR is being used to examine the patterns of expression that serve to assess the degree of P-stress experienced in the phytoplankton. To date, we show that the *phnD* gene is constitutively expressed, suggesting that freshwater picocyanobacteria are metabolizing exogenous phosphonate compounds in the severely P-limited environments. In contrast, we also provide evidence that *phoX* is regulated by P availability in Great Lakes picocyanobacteria. *Keywords: Phosphorus, Picocyanobacteria, Lake Erie, Gene expression, Lake Superior, P-limited.*

LALONE, C.A.[1], VILLENEUVE, D.L.[1], BURGOON, L.[2], TIETGE, J.E.[1], RUSSOM, C.L.[1], and ANKLEY, G.T.[1], [1]6201 Congdon Blvd., Duluth, MN, 55804; [2]109 T.W. Alexander Drive, Research Triangle Park, NC. **Molecular Target Homology as a Basis for Species Extrapolation to Assess the Ecological Risk of Pharmaceuticals.**

Adverse effects of many chemical contaminants, including human pharmaceuticals and other chemicals of emerging concern (CECs), are initiated through interactions with specific proteins within the cells of effected organisms. When protein targets of a given chemical are known--as is the case for many human pharmaceuticals--this information could serve as a basis for extrapolation of potential biological effects across species. Therefore, our work has focused on development of quantitative molecular homology-based approaches to predictive species extrapolation that could be used to prioritize pharmaceuticals, which are considered CECs in the Great Lakes, for potential adverse effects in aquatic organisms. Predictions about the sensitivity of the non-target species to the pharmaceutical are made based on amino acid alignment relative to the target species (e.g., humans) and associated metrics (e.g., % similarity, alignment quality, sequence integrity, and conservation of functional domains). Molecular targets and their corresponding protein accession numbers are identified using DrugBank. A computer program was developed to conduct seamless automated amino acid sequence alignments between target and non-target aquatic organisms to identify species with greater or lesser potential sensitivity to the pharmaceutical or CEC of interes
Keywords: Pharmaceuticals, Molecular homology, Computational tools.

LAMBERT, R.S., JONES, E.K., DEPETRO, P.A., and AUER, M.T., Michigan Technological University College of Engineering Department of Civil and Environmental Engin, 1400 Townsend Drive, Houghton, MI, 49931. **Bioavailability of Phosphorus entering the Great Lakes.**

Phosphorus (P) loads to the Great Lakes are managed based on total phosphorus. This approach does not reflect the fraction of the P that is available to algae. Here, bioavailability is determined using algal assays (Dual Culture Diffusion Apparatus) and chemical fractionation techniques. The bioavailability of soluble and particulate phase P is measured for the five largest US tributary sources to the Great Lakes: Maumee, Fox, Sandusky, Cuyahoga and Saginaw Rivers. In soluble experiments soluble reactive P was readily taken up by algae (100% bioavailable), and the dissolved organic P was taken up at a variety of rates by algae. Dissolved organic P bioavailability ranged from 20 to 95% in the Maumee and Fox Rivers, respectively. The initial concentrations of dissolved organic P were 12 to 95 µg/L in the Fox and Maumee Rivers, respectively. The initial soluble reactive P concentrations were 11 to 79 µg/L in the Sandusky and Cuyahoga Rivers, respectively. Algal bioassays and chemical fractionations on the tributary solids are being preformed, and results of this work will be presented. These results will facilitate the ranking and targeting of major contributors to Great Lakes loads based on the bioavailability of the P present there. *Keywords: Algae, Bioavailability, Phosphorus.*

LANSING, M.[1], BRODY, E.[2], STURTEVANT, R.A.[3], DRUMM, M.[4], HUTCHINSON, L.[5], WATERS, S.[6], DARNELL, C.[1], WINICK, J.[7], and BRYK, N.[4], [1]NOAA Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108; [2]NOAA Office of Marine Sanctuaries, Ann Arbor; [3]NOAA Great Lakes Sea Grant Network, Ann Arbor; [4]Ann Arbor Hands On Museum, 220 E. Ann St., Ann Arbor, MI, 48104; [5]Hutchinson Studios LLC, 21056 Robinwood Street, Farmington, MI, 48336; [6]NOAA Thunder Bay National Marine Sanctuary, 500 W. Fletcher Street, Alpena, MI, 49707; [7]1045 Olivia Ave, Ann Arbor, MI, 48104. **Forming new partnerships to reach new audiences: the creation and successful launch of a traveling Great Lakes educational exhibit, *Great Lakes Discovery*.**

In partnership with the Ann Arbor Hands on Museum (AAHOM) and Hutchinson Studios LLC, the NOAA Great Lakes Environmental Research Laboratory, NOAA Great Lakes Sea Grant Network, and NOAA Thunder Bay National Marine Sanctuary (TBNMS) designed and fabricated a traveling hands-on exhibit to advance Great Lakes and environmental literacy principles. *Great Lakes Discovery* combines hands-on activities and historic materials to engage visitors on Great Lakes science and maritime heritage. The exhibit experience is designed to stimulate family conversations about the Great Lakes and build a "sense of place" for residents in the region. *Great Lakes Discovery* is a pilot exhibit in the AAHOM's new system for traveling exhibits to free-choice learning centers (e.g., libraries, nature centers, etc.) to reach rural under-served communities with quality science education addressing ocean, Great Lakes, and climate literacy principles. Funded in part by a NOAA Preserve America grant, the exhibit was launched at the AAHOM, Ann Arbor Michigan in October 2010. The exhibit will relocate at the NOAA Great Lakes Maritime Heritage Center, Alpena, MI in June 2011, and other community venues in 2012 and beyond. *Keywords: Environmental literacy, Great Lakes basin, Public education, Communications, Environmental education, Partnerships.*

LANTRY, B.F.[1] and ESHENRODER, R.L.[2], [1]USGS Lake Ontario Biological Station, 17 Lake Street, Oswego, NY, 13126; [2]Great Lakes Fishery Commission, 2100 Commonwealth Blvd., Suite 100, Ann Arbor, MI, 48105. **Recent Changes in Successional State of the Deep-water Fish Communities of Lakes Michigan, Huron and Ontario.**

The deep pelagia of Lakes Michigan, Huron, and Ontario comprised about 60% of their volume and historically supported deepwater fishes adapted for extensive vertical migration. This specialized fish community was radically altered, beginning in the mid-1800s, by over fishing and introductions of alewife and sea lamprey. The ensuing extirpations resulted in severe successional setbacks in structure and function. Top-down control, initiated in the mid-1900s, consisted of sea lamprey control and reestablishment of top predators. This successional state too experienced setbacks, evident in Lake Huron by the mid-2000s, owing mainly to the 1980s introduction of Bythotrephes and two dreissenids. These introductions represented a form of bottom-up control that was followed by depletions of Diporeia, copepods and cladocerans and lead indirectly to

decreased production of Chinook salmon. We hypothesize that age-0 alewife were especially vulnerable to decreases in cladoceran populations, particularly of Daphnia and further that the induced response of Daphnia to Bythotrephes, a shift in vertical distribution downward to the upper hypolimnion, was catastrophic once dreissenids became dominant in the hypolimnion. These successional changes appear to be part of an ongoing process of oligotrophication with alewife as a key indicator. *Keywords: Alewife, Oligotrophication, Comparison studies, Successional states, Species composition, Deep pelagia.*

LAPLANTE, E.V.[1], STADLER-SALT, N.[2], and FINLAYSON, P.H.[3], [1]United States Environmental Protection Agency, 77 West Jackson Blvd., Mail Code: G-17J, Chicago, IL, 60604-3507; [2]Environment Canada, 867 Lakeshore Rd., Burlington, ON, L7R 4A6; [3]Environment Canada, 4905 Dufferin St., Toronto, ON, M3H 5T4. **Making a Great Lake Superior: 20 Years of the Lake Superior Binational Program.**

In 2011, the Lake Superior Binational Program will celebrate its 20th anniversary. The Binational Program seeks to restore and protect Lake Superior through: 1) the Lake Superior Lakewide Management Plan (LaMP), which focuses on the broader ecosystem; and 2) the Zero Discharge Demonstration Program, which seeks to achieve virtual elimination of targeted critical pollutants by 2020. This presentation provides an overview of the Binational Program as one example of large lake management that successfully integrates science, governance and action. Significant accomplishments from the past 20 years will be highlighted, including chemicals reduction, restoration and protection, fish and wildlife, and outreach. Challenges and Next Steps for the Binational Program will also be outlined, as well as opportunities for future research.
Keywords: Lake Superior, Lake management.

LARSON, D.L[1], MCNAUGHT, A.S.[1], and ROSEMAN, E.F.[2], [1]Department of Biology, Central Michigan University, Brooks Hall Room 151, Mt. Pleasant, MI, 48859; [2]USGS Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105. **Assessment of Nursery Habitat Use by Larval Fishes in the St. Clair River Delta, MI.**

Recruitment of fish into wetland nursery areas is critical during the larval stage, however, habitat factors responsible for good recruitment have been little studied. We surveyed twenty locations in the North and Middle Channels of the St. Clair River Delta between May and July 2010. Larval fish were collected weekly with a 0.5-m conical net and quatrefoil light traps to assess community composition and abundance. We measured a wide range of abiotic and biotic factors to establish differences between nursery areas. Nursery area use was quantified by number of individuals of each species and total abundance of fish collected. Spatial connectivity, or the position of a nursery area relative to the flowing channel, did not appear to affect larval fish abundances, as fish were present in areas that were both well connected and poorly connected to the main channel. Areas where localized water movement was high due to flow or wave action were not conducive to larval fish due to a lack of retention, whereas areas with low to moderate

water movement had higher fish abundances. Our data show that habitat use by larval fish is a product of localized water movement and may not depend on the proximity of a nursery area to main river channels. *Keywords: St. Clair River, Larval fish, Habitats, Coastal wetlands.*

LARSON, J.[1], STURTEVANT, R.A.[2], RUTHERFORD, E.S.[2], and FUSARO, A.[2], [1]School of Natural Resources and Environment, University of Michigan, Ann Arbor, MI, 48109; [2]NOAA Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108. **GLANSIS Organism Impact Assessment.**

The Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS - http://www.glerl.noaa.gov/res/Programs/ncrais/glansis.html) is a Great Lakes specific node of the USGS Nonindigenous Aquatic Species (NAS) system. GLANSIS has been selected as the backbone for AIS information reporting for the Great Lakes region under the Great Lakes Restoration Initiative. One of the most recent GLRI-funded enhancements to GLANSIS has involved an extension to the portion of the system which reports the impact of nonindigenous species. In addition to conducting a thorough review and update of reported impacts for each species, a new tool was developed which allows the level of impact to be assessed and compared across taxa. This organism impact assessment (OIA) tool is a quantitative scoring system based on qualitative criteria and provides a standardized method for analyzing and ranking the degree of socio-economic, environmental, and beneficial impact for each nonindigenous species. The incorporation of this information into GLANSIS has important implications for the improvement of this system as a tool for managers, policymakers, and educators. Thus far, OIA's have been completed for all fauna included in GLANSIS, and these results will be presented. *Keywords: Invasive species, Biological invasions, Assessments.*

LARSON, J.H., RICHARDSON, W.B., VALLAZZA, J.M., and NELSON, J.C., Upper Midwest Environmental Sciences Center, 2630 Fanta Reed Road, La Crosse, WI, 54603. **Relationships between watershed characteristics and food web structure in Lake Michigan rivermouth ecosystems.**

Coastal wetlands, particularly those at rivermouths, are areas of high biodiversity and productivity. These mixing zones between riverine and Great Lake waters are critical for early life-history stages development in many adfluvial and resident fish species, making them important foci for restoration and protection of Great Lakes fisheries. We hypothesize that rivermouth ecosystems are controlled by riverine inputs delivered by the upstream watershed, and Lake-derived inputs delivered by prevailing Lake currents and seiche events. We predicted that the importance of nutrients delivered by lake and river would vary based on upstream watershed characteristics, the magnitude and frequency of Lake seiche events and local anthropogenic and geomorphic features in the rivermouth. To test this prediction, we sampled nutrients, seston and basal consumers in a longitudinal design (river, rivermouth, lake) using food web biomarkers (N and C isotopes, fatty acids) to determine the source (lake or riverine) of food resources incorporated into the base of the food web at these locations. In total, 11 rivermouths surrounding Lake Michigan that varied in upstream watershed properties were sampled during the Fall of 2010. Results from this study have guided the development of a larger survey encompassing 30 sites across the Great Lakes basin. *Keywords: Watersheds, Tributaries, Estuaries.*

LAYDEN, A.M., MACCALLUM, S.N., and MERCHANT, C.J., School of GeoSciences, University of Edinburgh, Crew Building, King's Buildings, Edinburgh, EH9 3JN, United Kingdom. **Evaluation of factors determining the surface temperatures of large lakes worldwide, principally the seasonal cycles of solar radiation and ambient air temperature.**

Lake surface water temperature (LSWT) time series have been obtained by remote sensing for 263 globally distributed large lakes (principally those with surface area > 500km^2; Herdendorf 1982; Lehner and Doll, 2004), for the period 1995 to 2009. The remote sensing estimates used high quality infra-red imagery. The LSWTs are retained at 0.05 deg latitude-longitude resolution, each cell LSWT having an uncertainty of order 0.6 K. In addition, lake-mean temperature climatologies have been developed from the observations. Initial analyses considered, first, the latitudinal dependence of lake-mean LSWT climatologies over the annual cycle. As expected, the data display the responses of LSWT to the solar radiation cycle, with, for example, characteristic double LSWT maxima in the annual cycle of lakes at latitudes between 5^{o}S to 10^{o}N. Considering the relationship between LSWTs and ambient air temperature, at latitudes where air temperatures remain above freezing, mean LSWTs were found to be approximately 2-3^{o}C higher then mean air temperatures. The effect of elevation (0-5007 m a.s.l.) on seasonal maximum air temperature and LSWT determined that temperatures decrease approximately linearly with increasing altitude, at a rate of 4^{o}C km^{-1} (r^2 >0.93) *Keywords: Lake elevation, Ambient air temperatures, LSWT, Remote sensing.*

LEDDER, T.D., JERECZEK, J.C., LARSON, N.J., and ROBINSON, J., 1701 N 4th Street, Superior, WI, 54880. **Progress on delisting the St Louis River AOC through Hog Island Remediation to Restoration.**

The Great Lakes Areas of Concern (AOCs) are severely degraded geographic areas within the Great Lakes. Each AOC was charged with developing Remedial Action Plans to identify specific management strategies to restore beneficial uses in the AOC. The Hog Island Inlet/Newton Creek area is one in which a remediation to restoration project works toward this goal. This project was the second to utilize Great Lakes Legacy Funds and the first remediation to restoration. Planning targets were drafted by Minnesota and Wisconsin with input from local stakeholders to establish long-term goals for the AOC. This presentation contains information on these targets for potential partners interested in working on issues related to the restoration and delisting of the AOC. Beneficial Use Impairments on the St. Louis River relate to loss of habitat and contamination of sediments. The project at Hog Island Inlet and Newton Creek will be presented as an example of the process moving toward delisting of the St. Louis River AOC. Sediments were contaminated with PAHs and lead and mercury and produced oily sheens. Several projects have been completed removing sediment, stabilizing banks and initiating habitat restoration. The Master Restoration Plan was sponsored and funded by the USEPA GLNPO office. *Keywords: Remediation, Habitats, Decision making.*

LEE, I., CHOUNG, Y., and LI, R., 470 Hitchcock Hall, 2070 Neil Ave., Columbus, OH, 43210. **Lidar and Sub-meter Satellite Imagery for Lake Erie Shoreline Mapping.**

It will be a challenging task to have the autonomous shoreline extraction by using satellite or aerial imagery solely. Although bathymetric LiDAR can be use to extract tide-coordinated shoreline, the cost is relatively high and the quality of extracted shoreline will highly depend on the water clarity and LiDAR systematic error. This research conduct an investigation on mapping the Great Lakes shorelines by integrating airborne LiDAR data and the newly available 0.5-m-resolution World View 2 images for the achievement of fully autonomous instantaneous shoreline extraction with tolerable systematic error. Furthermore, tide-coordinate shoreline could also be estimated with a multiple set of instantaneous shorelines within a short time period. The accuracy of extracted instantaneous shoreline approaches 2 m. Bluffline erosion has been a severe environmental and economical issue along Lake Erie shore. This research also developed an autonomous procedure to extract blufflines based on airborne LiDAR point cloud. The accuracy of extracted bluffline approaches 1.5 m. These fully autonomous and cost-effective methods on the shoreline and bluffline extraction will benefit coastal researchers on coastal management activities. *Keywords: Boundaries, LiDAR, Lake Erie, Shoreline mapping, Satellite technology.*

LEGER, W.[1], READ, J.[2], and MORTSCH, L.D.[3], [1]Boundary Waters Issues Unit, Environment Canada, 876 Lakeshore Road, Burlington, ON, L7R 4A6; [2]Great Lakes Observing System; Michigan Sea Grant, 229 Nickels Arcade, Ann Arbor, MI, 48104; [3]Adaptation and Impacts Research, Environment Canada, 200 University Ave. W., Waterloo, ON, N2L 3G1. **Developing an adaptive management approach for managing the risks associated with Great Lakes water level changes due to climate change.**

The International Joint Commission (IJC) is conducting a 5-year International Upper Great Lakes Study to assess changes to the Lake Superior regulation plan. The goal is to meet contemporary and emerging needs, interests and preferences for managing the system in a sustainable manner, including significant alterations in water levels and flows due to climate change. The Study Board recognizes that lake level control structures at Sault Ste. Marie have minimal impact downstream on Lakes Michigan-Huron and the lower lakes, leaving a fairly large risk. The challenge for the multi-agency Adaptive Management Group is to identify approaches to shoreline management that address the largest areas of 'remaining risk' to high and low lake levels. The adaptive management approach includes: defining key vulnerabilities of 'interests'; evaluating risk

and options for addressing risk; determining long-term monitoring and research requirements; and undertaking institutional and governance analyses. This paper provides an overview of the conceptualization of adaptive management and the out-reach methodology as well as assesses the strengths and challenges of adaptive management.
Keywords: Planning, Great Lakes, Risk assessment, Adaptive management, Climate change.

LEGER, W.[1], READ, J.[2], MORTSCH, L.D.[3], FERREIRA, D.[1], and BROWN, C.[4], [1]Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [2]Great Lakes Observing System, 229 Nickels Arcade, Ann Arbor, MI, 48104; [3]Environment Canada, 200 University Ave. W., Waterloo, ON, N2L 3G1; [4]University of Massachusetts, 130 Natural Resources Road, Amherst, MA, 01003-9293. **Conceptualizing the Adaptive Management Approach for Managing the Risks Associated with Great Lakes Water Level Changes Due to Climate Change.**

The International Joint Commission (IJC) is conducting a 5-year International Upper Great Lakes Study (IUGLS) to assess changes to the Lake Superior regulation plan to meet contemporary and emerging needs, and interests and preferences for managing the system in a sustainable manner, including climate change scenarios. The regulation plan affects lake level, navigation, and hydroelectric production. However, the plan has minimal ability to manage impacts of high and low water levels downstream on Lakes Michigan-Huron and the lower lakes, since the Great Lakes system is constantly changing over time. This leaves a fairly large component of remaining risk. A multi-agency Adaptive Management Group is developing an adaptive management approach that includes: defining key vulnerabilities of 'interests'; assessing plausibility of risk; options for addressing risk; determining long-term monitoring and research requirements; and undertaking institutional and governance analyses as a means of developing a long-term adaptive management approach. This poster provides an overview of the conceptualization of the adaptive management approach. *Keywords: Great Lakes basin, Climate change, Risk assessment.*

LENTERS, J.D.[1], DONG, B.[1], HOLMAN, K.D.[2], and WANG, J.[3], [1]School of Natural Resources, University of Nebraska-Lincoln, Lincoln, NE, 68583; [2]Department of Atmospheric and Oceanic Sciences, University of Wisconsin-Madison, Madison, WI, 53706; [3]Department of Earth and Atmospheric Sciences, University of Nebraska-Lincoln, Lincoln, NE, 68588. **Rapid increases in lake surface temperature in recent decades: The potentially significant role of regional brightening.**

Recent in-situ and satellite-based studies of global lake surface temperature have provided clear evidence that many of the world's lakes are getting warmer, particularly since the early 1980s. In some regions - such as northern Europe, the Great Lakes, and the southwestern U.S. - lake surfaces are warming even more rapidly than the ambient air temperature. This is a rather surprising observation, considering the negative feedback that typically occurs as a result of enhanced evaporative cooling. In this study, we

propose a potential explanation for the paradoxical rapid warming that has occurred in some of the world's lakes in recent decades. Observations of rapid lake warming in the Great Lakes region from 1981-2006 are shown to occur at the same time as a period of significant decreases in summertime cloud cover - a regional manifestation of what is often referred to as "global brightening." Detailed analysis of the energy balance for a specific study lake in northern Wisconsin reveals that roughly half of the enhanced water temperature trend is due to increases in solar radiation, while the other half is simply the result of warmer air temperatures. Finally, we analyze global trends in solar radiation to investigate whether other regions with anomalous lake warming show a similar correspondence to regional brightening. *Keywords: Atmosphere-lake interaction, Climate change, Remote sensing.*

LEON, L.F., MCCRIMMON, G., BOOTY, W., YERUBANDI, R., and ZHAO, J., National Water Research Institute, 867 Lakeshore Rd., Burlington, On, L7R4A6, Canada.
Watershed & Lake Water Quality Modeling in Lake Winnipeg.

In recent years Lake Winnipeg has experienced an increase in the rate of eutrophication, mainly as a result of human activities, in particular due to non-point source pollution from farms and municipal wastewaters. Estimating non-point source pollution from watersheds and the effects of mitigation measures (e.g. beneficial management practices or BMPs) is an important step in managing and protecting water quality, not only at the basin level where it originates, but also at the receiving waters such as reservoirs, lakes or oceans. Simulation models at the watershed level have been applied to aid in the understanding and management of surface runoff, nutrients and sediment transport processes. Similarly, models with different degrees of complexity are used to simulate the aquatic ecology and water quality in the lake. We apply SWAT to three pilot watersheds in order to investigate the impacts and uncertainties of different BMPs on nutrient loading in the targeted watersheds. We also explore avenues for scaling and propagating such loads and uncertainties into the receiving lake models. In order to integrate with the watershed simulations, we used 3D and 2D hydrodynamic and ecological models (ELCOM-CAEDYM and OneLay-PolTra) which include processes to describe nutrient cycling, sediment transport and phytoplankton dynamics.
Keywords: Water quality, Modelling, Watersheds, Lake Winnipeg.

LESHKEVICH, G.[1] and SONGZHI, L.[2], [1]NOAA/Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108; [2]Cooperative Institute for Limnology and Ecosystems Research, 4840 South State Road, Ann Arbor, MI, 48108.
New Great Lakes CoastWatch Decision Support Tools.

CoastWatch is a nationwide National Oceanic and Atmospheric Administration (NOAA) program within which the Great Lakes Environmental Research Laboratory (GLERL) functions as the CoastWatch 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 data, and derived products to Federal and state agencies, academic institutions, and the public via the CoastWatch Great Lakes web site (http://coastwatch.glerl.noaa.gov). A new CoastWatch server running THREDDS (Thematic Real-time Environmental Distributed Data Services) for accessing and publishing scientific data in a convenient fashion will be available. In addition, a new Great Lakes coastal web atlas is being developed to allow online viewing and download of spatial data sets gathered from federal, state, and academic sources, including biological, physical, and political boundaries and infrastructure data. The atlas includes an interactive, user-friendly coastal and marine spatial planning tool that allows the spatial data sets to be used to support resource management decisions.
Keywords: Remote sensing, Satellite technology, Decision making.

LETCHER, R.J., CHEN, D., CHU, S.G., and GAUTHIER, L.T., Ecotoxicology & Wildlife Health Division, Science and Technology Branch, Environment Canada, National Wildlife Research Centre, Carleton University, Ottawa, ON, K1A0H3.
Current-Use Flame Retardants in Great Lakes Herring Gulls: (Non)Halogenated Organophosphates and Other Surprise Findings.

Environmental reports of possible (bio)accumulation of organophosphate flame retardants (OPFRs) date back to the 1970s. OPFRs have "re-emerged" as environmental contaminants, but to our knowledge there are no reports of OPFRs in wildlife. We developed a sensitive quantitative method for the determination of 15, non-halogenated, chlorinated or brominated OPFRs, and subsequently examined these FRs in the eggs of herring gull (*Larus argentatus*) collected in 2009 from 15 breeding colonies spanning the Great Lakes. Tris(1-chloro-2-propyl) phosphate concentrations ranged from 5.4 to 30.1, Tris(2-chloroethyl) phosphate from 1.1 to 7.9, tris(2-butoxyethyl) phosphate at levels up to 39, and triphenyl phosphate from 2.1 to 8.2 ng/g lipid weight. Tris(1,3-dichloro-2-propyl) phosphate was detected but not quantifiable, and tricresylphosphate was not detectable. When considering the other 9 OPFRs examined in this study, the sum of OPFRs were among the highest FRs found in herring gull eggs. Furthermore, for the first time ever in any environmental matrix, we report on the detection, characterization of several PBDE-like, BFR degradation products in Great Lakes herring gulls (eggs). Our results demonstrate the increasing complexity of FRs in Great Lakes herring gulls, and subsequently in their eggs, from dietary bioaccumulation. *Keywords: Environmental contaminants, Herring gulls, Bioaccumulation, Flame retardants, Great Lakes basin, Biotransformation.*

LI, H. and MINOR, E.C., Large Lakes Observatory, University of Minnesota Duluth, 2205 E. 5th St., Research Laboratory Building, Duluth, MN, 55812, United States.
Diagenetic Changes in Organic Matter in Lake Superior Sediments as Seen by FT-IR and 2D IR Correlation Spectroscopy.

Fourier-transform infrared spectroscopy (FT-IR) and 2D correlation analysis, where core depth and sample site were used as perturbations, were used to study the diagenesis of organic matter (OM) in Lake Superior sediments. At five lake stations, changes in OM composition were examined over a depth range of 0 to 10 cm. Analysis of synchronous spectra reveals that carbohydrates and carboxyl groups change to a great extent with increasing depth. Analysis of asynchronous spectra shows that, generally, carboxylic acids / fatty acids change first, along with C-O in lignin functional groups, followed by protein, carbohydrates, then biogenic silica. Similar trends are observed for 2D IR correlation spectra at the other stations, with some shifts in peak positions indicating that somewhat different structures within the basic compound classes are being altered as a function of site. 2D IR asynchronous spectra, where composition at the same depths at all stations are investigated, show that differences among sites decrease with increasing depth. This implies a preferential depletion of carboxyl groups, protein and carbohydrates during diagenesis and a shift toward similar refractory organic matter at each site. This study demonstrates the usefulness of 2D IR correlation spectra to explore structural changes in OM during diagenesis. *Keywords: Organic compounds, Lake Superior, Diagenesis.*

LICHTI, D.A. and CZESNY, S.J., Illinois Natural History Survey, University of Illinois, Lake Michigan Biological Station, 400 17th Street, Zion, IL, 60099. **Naturally Occurring Thermal Variation in Southwestern Lake Michigan May Greatly Affect Yellow Perch Growth During Embryonic and Larval Stages.**

In large and dynamic systems such as Lake Michigan, up-welling and down-welling events caused by strong winds can dramatically change thermal conditions in the nearshore. Yellow perch *Perca flavescens* spawn in this unstable environment where water temperature during their embryonic and larval stages can vary greatly. We examined impacts of drastic temperature change during embryogenesis on the growth of yellow perch. Eggs of five yellow perch females were fertilized. In the laboratory, each egg skein was sectioned and incubated under four temperature regimes: simulated down-welling, and up-welling, constant temperature, and Lake Michigan ambient temperature. We sampled embryos at three different times during development as measured in relative terms by degree days. Embryos were preserved in glutaraldehyde for morphological measurements. Differences in total length and size of oil globule were observed among treatments at each sampling interval. Our results indicate that the natural variation in thermal conditions experienced by feral yellow perch embryos may result in dramatic differences in growth and size at hatch which in turn may greatly influence early life history traits. *Keywords: Lake Michigan, Embryonic, Yellow perch, Growth, Temperature.*

LITTLE, B.J., LEE, J.S., and RAY, R.I., Naval Research Laboratory, 1009 Balch Blvd, Stennis Space Center, MS, 39529-5004. **Accelerated Corrosion in Duluth-Superior Harbor.**

Environmental factors that influence the corrosion rate of carbon steel sheet pilings (1.2 cm thick A328 cold rolled) in the Duluth-Superior Harbor (DSH), MN and WI, will be discussed. Pilings are scoured by ice in late winter and early spring resulting in a general loss of material. Localized corrosion on DSH pilings is characterized by tubercles, varying in diameter from a few millimeters to several centimeters, and when removed, large and often deep pits are exposed. The tubercles, made up of intact and/or partly degraded bacterial stalks mixed with amorphous hydrous ferric oxides, create reducing conditions beneath the tubercles that cause copper, dissolved in the water, to precipitate. A galvanic couple established between the copper layer and the iron substratum produces aggressive localized corrosion. Pit depth and weight loss have been measured at multiple locations over a 4-year period. Linear polarization resistance (LPR) measurements were made at the start of the study. Corrosion rates, calculated from the three independent techniques, vary with location. There are no obvious relationships between predicted corrosion rates derived from the three techniques. Water quality parameters that could influence corrosion rates have not been measured systematically. *Keywords: Tubercles, Corrosion, Lake Superior.*

LIU, H.[1] and FAMIGLIETTI, J.S.[2], [1]Department of Earth System Science, University of California,Irvine, Irvine, CA, 92697; [2]UC Center for Hydrologic Modeling, University of California, Irvine, Irvine, CA, 92697. **Simulating lake level variations using a catchment-based land surface model and a global scale forcing data.**

Modeling lake and reservoir level variations and changes in inundation extent are of great importance in simulating regional to global hydrology and climate interactions. The behavior of the terrestrial water cycle can be better represented by adding lakes and reservoirs to large-scale surface water routing models. This presentation shows the result of modeled lake levels for several large lake basins in the US and other continents(e.g., the Great Lakes in North America and Lake Victoria in Africa). In this study lakes are included in a coupled routing model and catchment-based land surface model, which is modified from the current version of Community Land Model (CLM). A NASA global/continental scale forcing data (GLDAS/NLDAS), modeled lake evaporation and discharge are used to calculate the water balance of each lake. Modeled lake level time series are compared with the 1992 to 2009 satellite altimetry data provided by the French LEGOS/GOHS. This lake water level model captured seasonal changes and the interannual trend of lake levels, and will ultimately be coupled to a global scale atmospheric model to study feedbacks between climate and the terrestrial surface water cycle. *Keywords: Hydrologic cycle, Lake model, Water level.*

LIU, P.C., NOAA/GLERL, 4840 S. State Rd., Ann Arbor, MI, 48108-9719.
Contemplating freaque waves in the Great Lakes.

Freaque (freak or rogue) waves seemed to have become media's favorite reporting events in recent years. Encountering with freaque waves have been reported from all around the world. Even though up to now we don't as yet even have a viable definition for freaque waves. One question, not infrequently asked, has been "Are there freaque waves in the Great Lakes?" That's not an easy question to answer, however, because there is no reason to say anything other than an affirmative "Yes!" But at the same time there is yet to have clearly reported cases per se other than the speculations that the 1975 sinking of SS Edmund Fitzgerald was caused by one. In this paper I expect to explore this question along with what do we know and how do we go about improving our knowledge base. I wish to stress firmly the need for extensive wave measurement in the Great Lakes, which is sorely inadequate at the present other than a few single point NDBC buoy measurements. Freaque wave research is still in the infantile stage, especially in the Great Lakes. Hopefully with increasing interest and measurements, one can at least try to reduce the mystic dilemma of being "freaque" in general wave understandings that's may be what media was attracted to in the first place. *Keywords: Air-water interfaces, Waves, Atmosphere-lake interaction.*

LIU, W., BOCANIOV, S.A., LAMB, K.G., and SMITH, R.E.H., Univeristy of Waterloo, Waterloo, ON, N2L 3G1. **Hydrodynamic-Biogeochemical Modeling of Lake Erie in 2008.**

As part of a three year project to investigate water quality problems in Lake Erie an intensive field program was conducted at the western end of the central basin of Lake Erie in 2008 and 2009. Hydrodynamic-biogeochemical modeling of the lake has been performed using ELCOM-CAEDYM. The model results are compared with the 2008 field observations of water temperature and circulation and with biogeochemical measurements to assess the ability of the model to simulate the nature of the physical-biological processes. Passive tracer movements are also investigated using both 2 km and 600 m resolutions to examine the sensitivity of model predictions of nutrient distribution in the lake. Results from these comparison will be presented. *Keywords: Hydrodynamic model, Lake Erie, Biogeochemistry.*

LIVINGSTONE, D.M., Eawag, Swiss Federal Institute of Aquatic Science and Technology, Duebendorf, CH-8600, Switzerland. **Spatial coherence and temporal change: The physical impact of large-scale climatic forcing and long-term climate change on inland waters.**

Inland waters, especially lakes, have traditionally been viewed as being driven by local, statistically stationary, meteorological forcing. This traditional view is now undergoing radical modification as a result of the recent recognition of the importance of large-scale, nonstationary climatic forcing in driving physical lake processes. Evidence

for the physical impact of large-scale climatic forcing and long-term climate change on inland waters, obtained primarily from long time-series of historical monitoring data, includes the existence of spatially coherent behavior in water temperature and ice phenology on scales of several hundred to several thousand kilometers, and the detection of the physical impact of a variety of large-scale climatic phenomena - including summer heat waves, abnormally mild winters, abrupt climate regime shifts and climate modes such as the Arctic Oscillation - on inland waters. The occurrence of long-term changes in the climatic boundary conditions that determine the physical behavior of inland waters, and hence their chemical and biological behavior, means that for the conservation and management of inland waters, knowledge based on past experience may no longer be a reliable predictor of the future. *Keywords: Climate change, Water temperature, Regional analysis.*

LOCHET, A.[1], MARSDEN, J.E.[1], FRYER, B.[2], and LUDSIN, S.A.[3], [1]University of Vermont, 3 College Street, Burlington, VT, 05401; [2]Great Lakes Institute for Environmental Research, 401 Sunset Avenue, Windsor, ON, N9B 3P4; [3]Ohio State University, 318W. 12th avenue, Colombus, OH, 43210. **Can statolith microchemistry be used to track natal origin of parasitic sea lamprey ?**

Sea lamprey parasitism is a major threat to Great Lakes fisheries. As part of the control efforts, lampricide treatments are performed annually to kill sea lamprey larvae in stream habitats. To improve efficiency of the lamprey control program, streams producing the most parasitic stages should be prioritized. Sea lamprey larvae from different streams can be discriminated based on the chemistry of their statoliths, calcified structures located in the inner ear. However, statolith microchemistry fails to identify the stream of origin of parasitic juveniles and spawners. The objective of this study is to test the chemical stability of statoliths through ontogeny. At the end of the larval stage, lampreys undergo a drastic metamorphosis. Such a change might affect statolith chemistry and make identification of natal origin of parasitic stage more difficult. 113 lampreys were collected in fall 2010 in four streams of different alkalinity: three Lake Champlain tributaries and one Lake Michigan tributary. Statolith chemistry was analyzed using LA-ICP-MS and compared between lampreys before and at the end of metamorphosis. Our study will determine if statolith chemistry is a valuable tool for sea lamprey control efforts. *Keywords: Fish management, Sea lamprey, Invasive species, Statoliths.*

LOCHNER, C.G.[1], BUTLER, R.L.[2], KLAWUNN, P.J.[1], and HILL, B.[1], [1]Environment Canada, Water Science and Technology, Canada Center For Inland Waters, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [2]Agriculture and Agri-Food Canada, 303 MAIN STREET, Cdn Grain Commission Bldg, Floor 2, Room 200, Winnipeg, R3C 3G7. **Assessing the Analytical Capabilities of Real-time Ultraviolet Spectrometry for Organic Contaminants in the Niagara River.**

Automated UV (Ultraviolet) spectrometers are being increasingly used in the industrial and wastewater sectors due to their compact, robust design and ability to collect UV absorption fingerprints as frequently as every minute. This study evaluates the capability of this technology to detect a variety of organic contaminants relevant to Environment Canada Water Quality Monitoring and Surveillance programs. Using the Niagara River as a test case, matched pairs of spiked Milli-Q reference water and matrix samples from the Niagara River at Niagara-On-The-Lake were prepared and analyzed using an S::CAN 100mm UV "Specto::lyzer". The matched pairs of UV absorption fingerprints were then compared to determine the analytical capabilities and limitations of the instrument. Contaminants studied include; legacy and current-use pesticides, chlorobenzenes, poly-aromatic hydrocarbons, and napthenic acids. *Keywords: Water quality, Real-time, Organic compounds, Niagara River.*

LOFGREN, B.M.[1] and PERROUD, M.[2], [1]NOAA/Great Lakes Environmental Research Lab, 4840 S. State Rd., Ann Arbor, MI, 48108; [2]CILER/University of Michigan, 4840 S. State Rd., Ann Arbor, MI, 48108. **Future Regional Climate Scenarios and the Importance of Ice.**

A few long-term simulations of regional climate change scenarios have been carried out using the Coupled Hydrosphere-Atmosphere Research Model (CHARM). As expected, these simulations show an increase in air and water temperatures as a result of increased greenhouse gases. They also exhibit warming in lake surface temperatures and a shift toward less ice cover during the winter. However, the historical record of ice cover on the Great Lakes has individual years ranging from almost no ice cover to near complete ice cover. This range is difficult to replicate in a climate model that couples the surface and atmosphere, especially over all five lakes simultaneously, and a bias in the basic state can affect the sensitivity of the hydrologic cycle to climate change. For example, if a historical simulation is tuned to have too little ice cover, future scenarios will have little ice to lose, and this can mean that the enhanced evaporation that can result from ice loss will be underestimated. *Keywords: Atmosphere-lake interaction, Ice, Climate change.*

LOHMANN, R.[1] and MUIR, D.[2], [1]University of Rhode Island, South Ferry Road, Narragansett, RI, 02882; [2]Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R4A6. **Using Passive Samplers To Detect Emerging PBTs In The Great Lakes.**

We plan to deploy passive samplers in lower atmosphere and surface water of several Great Lakes in 2011 to (i) enhance the measurements of the spatial variability of atmospheric concentrations of persistent bioaccumulative toxics (PBTs) around Lakes Superior, Erie and Ontario; (ii) assess whether the lakes are volatilizing or absorbing gas-phase PBTs to derive fluxes and loading to the lakes; and (iii) detect emerging contaminants of concern. By using the same sampling matrix (in our case polyethylene, PE) in air and water, we will derive activity gradients across the air-water interface and derive fluxes of pollutants. To use PE samplers to detect emerging PBTs in the Great

Lakes, and derive their ambient concentrations, we need to know the partitioning constants of the compounds between PE and water/air (KPE-w and KPE-air). For apolar chemicals, correlations with the respective Kow values can provide robust KPE-w values. For semi-polar contaminants, though, correlations with Kow are not adequate for deriving KPE-w values. In the case of selected contaminants, such as triclosan and alkylphenols, a good correlation was obtained of measured KPE-w with Khd-w values predicted from COSMOtherm. For the Great Lakes work, predicted KPE-w and KPE-air values and approximate detection limits are discussed. *Keywords: Environmental contaminants, Passive samplers, Air-water interfaces, Spatial analysis.*

LOHSE-HANSON, C.[1], BAILEY, J.[2], JERECZEK, J.C.[3], LAPLANTE, E.V.[4], MCCHRISTIE, M.[5], MOSES, S.[6], PREISSER, M.[7], and STADLER-SALT, N.[8], [1]Minnesota Pollution Control Agency, St. Paul, MN; [2]EcoSuperior Environmental Programs, Thunder Bay, ON; [3]Wisconsin Department of Natural Resources, Superior, WI; [4]EPA Great Lakes National Program Office, Chicago, IL; [5]Ontario Ministry of Natural Resources, Thunder Bay, ON; [6]Great Lakes Indian Fish and Wildlife Commission, Odanah, WI; [7]Michigan Department of Environmental Quality, Lansing, MI; [8]Environment Canada, Burlington, ON. **An Overview of Mercury Reduction Activities in the Lake Superior Basin.**

The Zero Discharge Demonstration Program (ZDDP) is a plan to achieve zero release of nine designated persistent bioaccumulative toxic substances in the Lake Superior basin. Mercury is one of nine chemicals targeted in the ZDDP. Partners from around Lake Superior, including federal, state, provincial, tribal, municipal, and community organizations have quantified mercury releases, set goals to reduce those releases, and worked towards achieving those goals in pursuit of a goal of zero mercury release in 2020. A number of planning documents, regulations, bylaws, research projects, education, recycling activities, and product collections have occurred over the 20 years of the program. Some of these actions were entirely due to the activities of the ZDDP, some were only influenced by it, and some would have occurred even without the program. While advances have been made in the use of mercury control technology and industrial awareness of mercury use and release has improved, mining and fuel combustion remain the most significant sources of mercury emissions in the basin. Decreasing the release of mercury while also encouraging sustainable development of the region's economy remains a significant challenge. *Keywords: Mercury, Lake Superior, Management.*

LOHSE-HANSON, C.[2], LAPLANTE, E.V.[1], GOMES, G.[3], BAILEY, J.F.[4], JERECZEK, J.C.[5], MCCHRISTIE, M.[6], MOSES, S.[7], PREISSER, M.[8], and STADLER-SALT, N.[9], [1]EPA Great Lakes National Program Office, Chicago, IL; [2]Minnesota Pollution Control Agency, St. Paul, MN; [3]Gomes Consulting Enterprises, Oakville, ON; [4]EcoSuperior Environmental Programs, Thunder Bay, ON; [5]Wisconsin Department of Natural Resources, Superior, WI; [6]Ontario Ministry of Natural Resources, Thunder Bay, ON; [7]Great Lakes Indian Fish and Wildlife Commission, Odanah, WI; [8]Michigan Department

of Environmental Quality, Lansing, MI; [9]Environment Canada, Burlington, ON. **Lake Superior Zero Discharge Demonstration 2010 Critical Chemical Milestones.**

The Zero Discharge Demonstration Program (ZDDP) is a plan to achieve zero release of nine designated persistent bioaccumulative toxic substances in the Lake Superior basin. The nine substances are mercury, PCBs, dioxin, hexachlorobenzene (HCB), octachlorostyrene (OCS) and four pesticides - dieldrin, chlordane, DDT and toxaphene. The reduction goals for mercury, dioxin, HCB and OCS are release reduction goals while for pesticides and PCBs the goals are safe destruction of accessible PCBs and collection of pesticides. The ZDDP targets only Lake Superior basin sources of these nine chemicals while acknowledging that out-of-basin sources contribute to the presence of these substances in the lake. The ZDDP has identified targets for staged reductions of these pollutants, with 1990 as the baseline year and 2020 as the year where zero release will be achieved. 2010 is a milestone year when the ZDDP reports on changes in the releases of the nine designated chemicals. This includes trends in releases of these chemicals, contaminant levels and trends in Lake Superior, and identification of further chemical reduction strategies. Preliminary analysis indicates that mercury reduction is close to the 2010 goal but dioxin is not as close. PCB and pesticide data indicate a flattening trend in the cumulative disposal of these materials. *Keywords: Toxic substances, Lake Superior, Management.*

LONDER, J.G.[1], BUNNELL, D.B.[2], CHRISCINSKE, M.A.[2], STOTT, W.[2], and DIANA, J.S.[1], [1]University of MIchigan, School of Natural Resources and Environment, 440 Church St., Ann Arbor, MI, 48109-1041; [2]USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48109. **Winter diet of sculpins from the abysses of northern Lake Michigan.**

Deepwater (Myoxoxcephalus thompsonii) and slimy (Cottus cognatus) sculpins live in the "abysses" of the Great Lakes (70-150 m), and their diets have been described in spring, summer and fall. We sought to describe their winter and early spring diet in Lake Michigan to determine whether these egg predators consumed incubating bloater (Coregonus hoyi) eggs, given declines in bloater recruitment. We were also interested in the extent to which sculpins consume Diporeia spp., which are now rare in Lake Michigan. We analyzed more than 1200 sculpin collected January-May in 2009 and 2010 at four sites in northern Lake Michigan at depths from 76-128 m. Eggs were identified to species using DNA bar-coding. Determining diet proportions and frequency of prey occurrence allowed comparative diet analyses between and within sculpin species across depths, locations, and months. Analyses revealed that inter- and intraspecific diet differences occur spatially and temporally but discernible patterns emerged for groupings based on location, depth and month. Preliminary analyses indicate eggs are 5.1% and 5.0% of deepwater and slimy sculpin diets, respectively. Of these eggs, about 20% are bloater, with the remainder being deepwater sculpin. Findings will assist in understanding the structure and function of deepwater food webs in the Great Lakes. *Keywords: Fish diets, Sculpins, Lake Michigan, Bloater, Benthivore.*

LOZANO, S.J., 4840 South State Road, Ann Arbor, MI, 48108. **The Status of the Benthic Community in Lake Ontario from 2004 to 2008.**

The benthic deep-water benthic community in Lake Ontario has been transformed over the last 15 years. Two important members of the community are showing the most dramatic change. The density and biomass of Diporiea and Dreissena were examined in Lake Ontario between 1994 and 2008. Average densities of Dreissena, i.e. combining densities of D. polymorpha and D. rostriformis bugensis, increased from 640 m2 to 9,900 m2 between 1997 and 2008. In contrast, average densities of Diporiea declined from 2,500 m2 to 40 m2 between 1997 and 2008. Densities were converted to biomass. Average Dreissena biomass increased to 290 g/m2 by 2008 while Diporiea biomass declined from 12 g/m2 to 0.2 g/m2. *Keywords: Diporeia, Lake Ontario, Dreissena.*

LU, X., BADE, D.L., LEFF, L., HEATH, R.T., and MOU, X., 222 Cunningham Hall Biological Sciences, Kent State University, Kent, OH, 44242. **Denitrification Is More Important Than Anammox In Microbially-Mediated N Removal In Lake Erie.**

Denitrification and anaerobic ammonium oxidation (anammox) are two microbially mediated processes that lead to removal of fixed nitrogen (N) from natural environments. Recent studies have indicated that anammox may contribute more than denitrification to nitrogen loss in some marine systems. To date, the relative contribution of these two processes in freshwater systems is poorly understood. Denitrification and anammox both require anaerobic conditions, which are common in the central and western basins of Lake Erie (LE) in summer. To compare the relative importance of anammox and denitrification in N removal in LE, deep water and surface sediment samples from the Sandusky Bay, the western basin and the central basin were analyzed for their potential N_2 production using a ^{15}N-incubation assay. Denitrification activity was present in all water samples, while anammox activity was found only in deep water samples from the central basin and at a rate much lower than denitrification. Diagnostic genes for denitrification (nosZ) and anammox (16S rRNA) were amplified from all samples, except Sandusky Bay samples, and their diversity was assessed by PCR-based clone library construction and sequencing. Our results indicate that anammox activity exists in LE but is less important than denitrification in removal of N.
Keywords: Anammox, Denitrification, Lake Erie.

LUO, L.[1] and WANG, J.[2], [1]Cooperative Institute for Limnology and Ecosystems Research (CILER), University of Michigan, Ann Arbor, MI, 48109-1041; [2]Great Lakes Environmental Research Laboratory (GLERL), NOAA, Ann Arbor, MI, 48108-9719.
Modeling ecosystem in Lake Michigan.

A lower trophic level food web model was used to investigate the ecosystem dynamics in Lake Michigan. Since Lake Michigan is characterized as a phosphorus-limited lake ecosystem, the biological model includes ammonium, nitrate, nitrite, phosphate and silicate for nutrients, phytoplankton, zooplankton, detritus, and dissolved oxygen (DO). The model was driven by the physical fields derived from unstructured-grid ocean model FVCOM and observed external loading. The temporal and spatial distributions of nutrients, phytoplankton, zooplankton and DO were simulated. The fluxes between the food web components were estimated. The model results are validated with observations. The model is able to capture the major characteristics of the ecosystem in Lake Michigan over a seasonal cycle. *Keywords: Ecosystem modeling, Lake Michigan.*

MA, Y., VENIER, M., SALAMOVA, A., and HITES, R.A., School of Public and Environmental Affairs, Indiana University, Bloomington, IN, 47405. **Alternative flame retardants in the atmosphere over the Great Lakes.**

New flame retardants are continuously introduced into the market as possible alternatives to the now discontinued polybrominated diphenyl ethers (PBDEs). We report here the identification and quantitation of some alternative flame retardants [i.e. pentabromotoluene (PBT), tetrabromo-p-xylene (pTBX), 2-ethylhexyl-2,3,4,5-tetrabromobenzoate (EHTBB), bis(2-ethyl-1-hexyl)tetrabromophthalate (BEHTBP), 2,3-dibromopropyl-2,4,6-tribromophenyl ether (DPTE), a-, b-, g-, and d-tetrabromo-ethylcyclohexane (a-, b-, g-, and d-TBECH), 2-bromoallyl-2,4,6-tribromophenyl ether (BATE), allyl 2,4,6-tribromophenyl ether (ATE), decabromodiphenylethane (DBDPE), and Dechlorane Plus (DP)] in the vapor and particle phases in the atmosphere over the Great Lakes as part of the Integrated Atmospheric Deposition Network (IADN). Although the atmospheric concentrations observed are not now as high as those of PBDEs, the levels of these compounds are expected to increase in the future, given that these compounds are likely to be used as alternatives to the banned PBDEs and given that the demand for flame retardants in the global market will continue to increase. *Keywords: Atmospheric circulation, Environmental contaminants, IADN.*

MACCOUX, M.J.[1], DOLAN, D.M.[1], and CHAPRA, S.C.[2], [1]University of Wisconsin - Green Bay, Natural and Applied Sciences, Green Bay, WI, 54311; [2]Tufts University, Civil and Environmental Engineering, Medford, MA, 02155. **Chloride and Total Phosphorus Loadings (1994-2008) and a Mass Balance Model for Green Bay and Lake Michigan.**

Green Bay experiences poor water quality due to high TP loading from the Fox River, for which a TMDL has been proposed. Chloride and TP loadings for the period of 1994-2008 have been estimated for Lake Michigan as part of an EPA-GLNPO research grant. Tributary loadings comprised the majority of both chloride and TP loadings. Point source loadings remained relatively stable with a slight decline over the 15-year period. Total loadings exhibited no trends during this time, although chloride concentrations continue to increase. The loading data was used to update a mass balance budget model for Green Bay and Lake Michigan. The chloride model exhibited excellent agreement, and TP agreement was generally good, with the exception of large differences in lower

Green Bay during 1999-2004. The source of the deviance remains unclear, but sediment resuspension and hypoxic release of phosphorus are believed to have caused significant internal loading. The Lower Fox River TMDL and other load reductions were modeled. Predicted steady state concentrations coincide with the multiple regression model results used in the TMDL development. The effects of meeting the TMDL beyond the lower bay included significant reductions in phosphorus, which may influence phosphorus management strategies in the upper bay. *Keywords: Phosphorus, Mass balance, Water quality.*

MACINTYRE, S., FRAM, J.P., VIDAL, J., and EMERY, B., Marine Science Institute, University of California at Santa Barbara, Santa Barbara, CA, 93117. **Comparative Mixing Dynamics in Arctic Lakes of Diverse Sizes.**

Regional studies have demonstrated synchrony in temperature between lakes of different sizes and unexplained differences. Here, we present the results of comparative analyses of the meteorological forcing, thermal structure, and mixing dynamics of five arctic lakes located within 10 km of each other and ranging in size from 1 to 150 ha. Four are dimictic and one is polymictic. Heating and cooling were synchronous within the lakes, but surface temperatures during warm fronts were 2 - 3 oC warmer in the smaller dimictic lakes and the polymictic lake than in the larger lake. Cold night time temperatures drove gravity currents in the smaller lakes which intruded between the warmed surface layer and the thermocline. Of the stratified lakes, all have events in which Lake numbers, indicative of the potential for non-linear internal wave breaking and mixing, drop to critical values. Such events were rare in the 1-3 ha lakes, but more frequent in the 11 ha lake than in the 150 ha one. Year to year prevalence depended on the frequency of frontal systems and whether high or low pressure systems were to the north. Slight density gradients in spring often retarded convective mixing at ice off. Whether non-linear wave induced mixing followed ice off determined whether the lakes fully mixed and persistence of near bottom hypoxia. *Keywords: Arctic, Hydrodynamics, Atmosphere-lake interaction.*

MAITY, S.[1], JANNASH, A.[2], ADAMEC, J.[3], GRIBSKOV, M.[4], HOOK, T.O.[1], and SEPULVEDA, M.S.[1], [1]Department of Forestry and Natural Resources, Purdue University, 195 Marsteller St., West Lafayette, IN, 47907; [2]Bindley Bioscience Center at Discovery Park, Purdue University, 201 South University Street, West Lafayette, IN, 47907; [3]Department of Biochemistry, Beadle Center N151, University of Nebraska, 1901 Vine Street, Lincoln, NE, 68588; [4]Department of Biological Sciences, Purdue University, 915 West State Street, West Lafayette, IN, 47907. **Study of *Diporeia* Physiology in Response to the Diatom Diet and Polychlorinated biphenyl (PCB) Exposure Using Metabolomics.**

Diporeia spp., a benthic macroinvertebrate in the Laurentian Great Lakes has experienced a significant population wide decline since 1990s. Our research is focused on studying the impacts of environmental stressors (i.e., food quality/quantity (diatoms), exposure to contaminants (polychlorinated biphenyls)) on *Diporeia* metabolome. Metabolic profile of each *Diporeia* was collected using GC-GC/MS-TOF and LC/MS-TOF for metabolomics study. Preliminary results suggest stressor-specific differential metabolite expression pattern between control and treatment group. Metabolomic analyses of non-polar metabolites (LC/MS-TOF) have detected increased rate of fatty acid synthesis and decreased amino acid metabolism (diatom feeding trial), enhanced hydrocarbon receptor mediated pathways (PCB exposure) while similar analyses of polar metabolites (GCXGC/MS-TOF) have identified enhanced glycoside dependant flavanoid and ascorbic acid pathway (diatom feeding trial), up-regulated protein catabolism and quinone metabolism (PCB exposure) in experimental samples. By comparing these results with metabolome of field samples, we hope to understand causative factors responsible for *Diporeia* decline in the wild. *Keywords: Diatoms, PCBs, Diporeia, Metabolism.*

MANDRAK, N.E.[1] and THOMPSON, A.[2], [1]Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [2]Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Predicting Spawning Locations for Asian Carps in Great Lakes Connecting Channels using Particle Tracking Models.**

As Bighead and Silver carps are on the doorstep of the Great Lakes, there is much interest in determining where they could survive and reproduce, and their impact. Earlier risk assessments answered these questions within the broader context of North America. These earlier risk assessments did predict where they could reproduce in the Great Lakes, but on a rudimentary level considering tributaries having an unimpounded length of at least 80 km as potentially suitable spawning streams. However, the connecting channels of the Great Lakes were not assessed. In this study, the suitability of the connecting channels for Asian carp spawning is evaluated. Successful spawning is thought to require the eggs to drift until they hatch, and the larvae to settle in highly productive areas such as wetlands. Hatching time is dependent on temperature, and drift time is dependent on water velocity. Two-dimensional reverse particle tracking models were used to calculate the potential locations of spawning from wetland end points. The model was seeded with minimum and maximum drifts times based on published hatching rates and mean biweekly water temperatures. The results for the Detroit and St. Clair rivers will be presented. *Keywords: Biological invasions, Hydrodynamic model, Risk assessment.*

MANNING, N.F.[1], MAYER, C.M.[1], BOSSENBROEK, J.M.[1], TYSON, J.T.[2], and BUNNELL, D.B.[3], [1]University of Toledo Lake Erie Center, 6200 Bayshore Rd., Toledo, OH, 43616; [2]Lake Erie Headquarters, 305 E. Shoreline Drive, Sandusky, OH, 44870; [3]USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105. **Use of Individual Based Models to Explore the Effects of Turbidity on Early Life History Traits of Yellow Perch (Perca flavescens).**

Turbidity is an environmental factor that affects the foraging, growth, and survival of age-0 fish. Many aquatic ecosystems are affected by high turbidity, especially areas that receive discharge from large rivers, which provide a major source of suspended solids and nutrients. Laboratory experiments show reduced larval feeding rates of age-0 yellow perch with increasing phytoplankton turbidity and a significantly lower juvenile feeding rate with phytoplankton and sediment -derived turbidity. In previous work in western Lake Erie, we identified turbidity as the most important environmental factor in driving the abundance and size of age-0 yellow perch in August . Here, we provide results from an individual based model that sought to determine how turbidity intensity and type influence larval yellow perch growth and survival. We used laboratory derived feeding rates to set daily ingestion rates and modify predation risk. We found that turbidity type and intensity alter feeding rates, reducing growth in cohorts exposed to high algal turbidity, and increasing growth in those exposed to high sediment turbidity. High levels of turbidity also provide a reduction in predation mortality by hindering the predator's ability to successfully detect and capture larvae. *Keywords: Turbidity, Individual Based Models, Yellow perch.*

MANNY, B.A.[1], KENNEDY, G.W.[1], BOASE, J.C.[2], CRAIG, J.M.[1], and ROSEMAN, E.F.[1], [1]USGS Great Lakes Science Center, 1451 Green Rd, Ann Arbor,, MI, 48105; [2]USFWS, Waterford Fisheries Station, 7806 Gale Rd., Waterford,, MI, 48327. **Fish response to construction of fish spawning habitat in the Detroit River.**

Loss of fish habitat is a beneficial use impairment in the Detroit River Area of Concern. Spawning habitat for native fish was constructed at two locations in the Detroit River: in US waters near Belle Isle in 2004 and in Canadian waters near Fighting Island in 2008. Substrates used at Belle Isle included large broken limestone, large round cobble, and coal cinders. Substrates used at Fighting Island consisted of medium broken limestone, small broken limestone, and medium round cobble. At both Belle Isle and Fighting Island, the constructed habitat was quickly used by native fish for reproduction. Fourteen and 12 species of native fish were captured, respectively, on the spawning substrates as adults in spawning-ready condition or hatched from eggs collected on the spawning grounds with furnace-filter egg mats. Among the fish at both locations were spawning-ready adults or eggs of Lake Sturgeon, Walleye, Lake Whitefish, and numerous sucker species. Results showed that loss of spawning habitat for native fish can be successfully remediated in the Detroit River Area of Concern by construction of spawning habitat on the river bottom. Continued fishery assessment will show whether the constructed habitat is sustained by natural river forces. *Keywords: Habitats, Fish, Remediation.*

MANZO, L.M.[1] and FORTNER, R.W.[2], [1]Ohio Sea Grant, 1314 Kinnear Road, Columbus, OH, 43214; [2]COSEE Great Lakes, 113 Paula Circle, Oak Island, NC, 28465. **Introducing the Great Lakes Literacy Essential Principles and Fundamental Concepts for Great Lakes Learning: An Educational Framework to Enhance Research Proposals.**

The ocean sciences community now has literacy principles for all of North America, including the nation's freshwater coast. *Great Lakes Literacy Essential Principles and Fundamental Concepts for Great Lakes Learning* has been developed as a means of comparing the oceanic attributes of the lakes with the well-established *Ocean Literacy Essential Principles and Fundamental Concepts*, so that educators (K-16 and informal) and scientists would think of the Great Lakes in parallel with the oceans. Beginning in 2009, COSEE Great Lakes education leaders in the Great Lakes Sea Grant Network examined existing Ocean Literacy and Lake Erie Literacy documents and drafted a baseline set of Great Lakes concepts. After input and editing by over 80 scientists and educators in Great Lakes states, Ohio Sea Grant educators then synthesized and organized the best ideas from examiners and oversaw a final review of the concepts. The poster resulting from this process will introduce researchers to the *Great Lakes Literacy Essential Principles and Fundamental Concepts*. Scientists can use the framework to strengthen the broader impact component of grants and proposals, as referencing the principles and concepts allows funding sources to see how field research aligns with regional Great Lakes education efforts. *Keywords: Education, Great Lakes literacy, Environmental education, Public education.*

MAREK, R.F.[1], PERRY, S.S.[2], THORNE, P.S.[2], DEWALL, J.[2], and HORNBUCKLE, K.C.[1], [1]Dept. Civil and Environmental Engineering, College of Engineering, The University of Iowa, Iowa City, IA, 52242; [2]Dept. Occupational and Environmental Health, College of Public Health, The University of Iowa, Iowa City, IA, 52242. **PCBs and OH-PCBs in Children and Their Mothers Living in Urban and Rural Communities.**

We have analyzed human blood serum collected since 2008 from adolescent children and their mothers in urban East Chicago, Indiana (n >100) and rural Columbus Junction, Iowa (n >100) for more than 200 PCB congeners and 11 hydroxlyated PCBs (OH-PCBs). We used highly selective methods and a full suite of quality control measures to optimize the analytical method for our target compounds. East Chicago is a heavily-industrialized residential community on the southwestern shore of Lake Michigan. Bisecting the area, and passing within 2 km of two schools, is the Indiana Harbor and Ship Canal. In contrast, residents of the rural Columbus Junction area have no known PCB exposure from current or past industrial sources. Despite the obvious differences in the two environments, we found the PCB concentrations in the two cohorts of people to be statistically similar although the variability of concentrations in both cohorts is quite large. The median values for PCBs and OH-PCBs in this large set of samples is generally lower than has been reported for human serum samples collected 10 or more years ago. It is not clear if these lower levels are due to the large sample size, characteristics of the populations, or are reflective of declining levels of PCBs in humans world-wide. *Keywords: Human health, PCBs, Lake Michigan.*

MARSDEN, J.E.[1], KELSEY, K.[2], HONEYFIELD, D.[3], and RILEY, S.C.[4], [1]University of Vermont, Burlington, VT, 05405; [2]Ed Weed Fish Culture Station, 14 Bell Hill Road, Grand Isle, VT, 05458; [3]Northern Appalachian Research Laboratory, 176 Straight Run Road, Wellsboro, PA, 16901; [4]U. S. Geological Survey Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105. **Changes in egg thiamine concentrations in lake trout and Atlantic salmon after alewife invasion of Lake Champlain.**

Alewife invaded the Great Lakes in the 1930s after severe changes in native predator and prey populations, and are now a major prey of stocked salmonids. Due to high thiaminase in alewife, salmonid fishes that consume alewife allocate insufficient thiamine to their eggs, and their fry suffer from early mortality. Alewife appeared in Lake Champlain in 2003, where a relatively intact native predator/prey community is present, though salmonids are maintained by stocking. The purpose of this study was to determine how rapidly the presence of alewife would result in changes in egg thiamine and fry survival in native salmonids. We monitored thiamine levels in lake trout and Atlantic salmon eggs since 2004, and examined thiaminase levels in alewife and native smelt. Thiamine levels prior to the expansion of alewife abundance were normal (11.5 - 14.8 nmol/g average/year), but by 2010 thiamine had dropped to an average of 4.4 in lake trout and 2.3 in salmon. Alewife thiaminase levels varied between 5 and 8 umol/g from 2006 to 2010. Symptoms of thiamine deficiency were widespread in hatchery-reared fry from feral salmonid eggs beginning in 2008. These data indicate that alewife may present a new impediment to salmonid restoration in Lake Champlain. *Keywords: Alewife, Invasive species.*

MARTI, C.L. and IMBERGER, J., Centre for Water Research, The University of Western Australia, 35 Stirling Highway MO23, Perth, WA, 6009, Australia.
Implementation of a Real-time Management System in the Swan Canning River Basin and its receiving waters (Western Australia, Australia).

The Swan-Canning River Basin, the central feature of Perth (Western Australia, Australia), has undergone extensive land use changes since European settlement, and is continuing to face severe threats from urban development, climate change and agricultural land use. To assist with the ongoing sustainable management of the River Basin, we have developed a web-based Real-time Management System (RMS) incorporating data acquisition, data visualization and management, 3D simulations of the estuarine hydrodynamics and ecology, scenario hindcasting and forecasting. The system also allows for schools to embed student projects within the online environment. The objective of the system is to allow the Swan-Canning River Basin and its receiving waters to be managed sustainably for the benefit of the community, taking advantage of new web and communication technologies. *Keywords: Monitoring, Modelling, Hydrodynamics, Environmental education, Data acquisition.*

MARTINEZ, A. and HORNBUCKLE, K.C., 4105 Seamans Center for the Engineering, Iowa City, IA, 52242. **Record of PCB congeners, sorbents and toxicity in core samples from Indiana Harbor and Ship Canal.**

Indiana Harbor and Ship Canal (IHSC), a tributary of Lake Michigan, will be dredged in the near future. Through the collection of two core samples in IHSC we have attempted to record the amount of PCBs, congener profile distribution, sorbent types and toxicity in this system. Vertical distributions of ΣPCBs ranged from 0.4 to 91 and 1.8 to 41 ppm for cores 1 and 2, respectively. Core 1 showed its highest accumulation rate for the year 1979 (1890 mg m-2 yr-1). PCB signature in most of Core 1 has a strong Aroclor 1248 signal, suggesting that little microbial degradation has occurred for the last ~60 years. Core 2 also has a strong Aroclor 1248 signal in the top layers, but deeper layers show evidence of mixtures of Aroclor and/or weathering processes. High levels of black carbon as a fraction of total organic carbon were found in both cores (median ~30%), which reflect the impact of local combustion sources into this system. No strong relationship was found between ΣPCB concentration and sorbents. Both cores show important values of TEQs, higher than the current surficial values, which in the event of dredging could be left as surficial sediments. *Keywords: PCBs, Sediments, Environmental contaminants.*

MAYER, D.A., GAYLO, M.J., and MOLLOY, D.P., Division of Research and Collections, New York State Museum, Albany, NY, 12230. ***Pseudomonas fluorescens*** **Strain CL145A as a Biopesticide for the Control of Zebra and Quagga Mussels.**

Scientists at the New York State Museum discovered a strain of the common soil bacterium, *Pseudomonas fluorescens* (strain *Pf*-CL145A) that has the unique capacity to cause lethality to zebra and quagga mussels (*Dreissena* spp.). *Pf*-CL145A is as effective whether the cells are alive or dead, indicating that mussels die from the impacts of a toxin rather than infection. Histological observations of exposed dreissenid mussels indicate that the toxin destroys the epithelial lining of the tubules in the mussels' digestive gland. The toxin activity is short-lived in natural waters and aquatic non-target testing has demonstrated extraordinary specificity to dreissenids, thus reducing the risk of environmental impacts from product applications. Potential applications will be discussed including the reduction of biofouling within industrial infrastructures, such as cooling water systems in power plants, as well as a discussion of potential open water applications for preventing the spread of larval dreissenids in fish transport water (fish hatchery stocking protocols, live wells, bait buckets, etc.), and applications to reduce fouling by dreissenids on native freshwater mussels. *Pf*-CL145A is being commercialized under the product name Zequanox *Keywords: Management, Biopesticide, Dreissena.*

MAYORGA, P.[1] and BOYER, G.L.[2], [1]Servicios y Productos Ambientales, SEPRA, Guatemala City, Guatemala; [2]SUNY College of Environmental Science and Forestry, 1 Forestry Drive, Syracuse, NY, 13210. **The Occurrence of Cyanobacterial Toxins in Lake Atitlan, Guatemala - A Cautionary Tale for Toxic Cyanobacteria Research in the Great Lakes.**

Blooms of cyanobacteria have increased in severity and frequency over the past decades as global pressure on a finite supply of freshwater increases. These blooms can result in large amounts of algal biomass, leading to both unsightly conditions, taste and odor issues in drinking water, disruption of ecosystem functions, and possible production of a wide variety of toxins. In 2009, Lake Atitlan, Guatemala, experienced a massive outbreak of *Lyngbya hieronymusii* due to nutrient inputs from land use practices and the failure of local wastewater treatment facilities as a result of storm damage. The popular media, internal politics, and limitations in analytical chemistry led to the widespread characterization of this lake as contaminated by "toxic" algae. Subsequent analysis of samples collected from Lake Atitlan showed that water samples had very low levels of cyanobacterial toxins and, while the water quality was significantly impaired by the *Lyngbya* blooms, toxicity from known cyanobacterial toxins, was probably not a major concern. These results will be compared to recent studies on Lake Erie and Lake Ontario, especially in regards to the difference between potentially-toxic species, toxic species and non-toxic species reported to produce different cyanobacterial toxins. *Keywords: Toxic substances, Lake Atitlan, Cyanophyta, Guatemala, Nutrients.*

MCDANIEL, T.V.[1], NEILSON, M.[2], CHANDLER, J.[3], FAVERI, G.[2], GRIM, L.[3], SAUNDERS, K.[2], and BOURGET, E.[3], [1]Environment Canada, 867 Lakeshore Rd E, Burlington, ON, L7R 4A6; [2]Canadian Member I.L.W.R.R.W.Task Force., P.O. Box 5150, 808 Robertson St., Kenora, ON, P9N 3X9; [3]US Member ILWRRW Task Force, 808 Carmichael Rd #200, Hudson, WI, 54016. **IJC International Lake of the Woods and Rainy River Watershed Task Force: Shared Waters, Shared Management-What is the Best Approach?**

Water quality within the Lake of the Woods (LOW) and the Rainy River watershed is of growing public concern. Several local groups and governments have called for the involvement of the International Joint Commission (IJC) in dealing with existing and emerging pollution issues within the watershed. The IJC appointed the International Lake of the Woods and Rainy River Watershed Task Force to help respond to a reference from the Governments of Canada and the United States to develop recommendations regarding bi-national management of the Lake of the Woods and Rainy River watershed and the IJC's potential role in this management. The Task Force's main tasks are to review the ways that the governments of Canada and the United States work together to manage water quality, water quantity and related issues in the watershed, to identify gaps in the current approach, to identify key existing or emerging issues that require attention, and to recommend any new or adjusted governance mechanisms that would help address the identified future needs. This presentation will highlight some of the existing bi-national governance mechanisms with options on how they can be

modified to address current issues in water quality and quantity. *Keywords: Policy making, Lake Winnipeg, Watersheds.*

MCGOLDRICK, D.J.[1], DURHAM, J.[2], LEKNES, H.[3], KIERKEGAARD, A.[4], and GERHARDS, R.[5], [1]Water Science & Technology Directorate, Environment Canada, Burlington, ON, L7R 4A6; [2]Dow Corning Corporation, Midland, MI; [3]NILU - Norwegian Institute for Air Research, Kjeller, Norway; [4]ITM - Stockholm University, Stockholm, Sweden; [5]Evonik Goldschmidt GmbH, Essen, Germany. **Assessing inter-laboratory comparability and limits of determination for the analysis of cyclic volatile methyl siloxanes in whole Rainbow Trout (*Oncorhynchus mykiss*).**

Cyclic volatile methyl siloxanes (cVMS) are high volume production chemicals used in a wide range in industrial and consumer products. Three cVMS compounds (D4, D5, and D6) have or are undergoing environmental risk evaluations in several countries and have been proposed for legal regulation in some. As interest in monitoring the concentrations of these chemicals in the environment increase, there is a need to evaluate the analytical procedures for cVMS in biological matrices in order to assess the quality of the data produced. The purpose of this study was to determine laboratory testing performance for measuring residues of D4, D5, and D6 in a standard set of fish homogenate samples and to estimate limits of determination for each substance. The samples sent to each laboratory consisted of homogenized whole body tissues of hatchery raised rainbow trout which were fed food fortified with D4, D5, and D6 (dosed) and trout that were fed standard food rations (control). The participants analyzed the samples using their analytical method of choice as well as their own standards and quantification procedures. Participating laboratories generated comparable results for D4, D5, and D6 in each sample as determined by Z-scores. Method detection limits (MDL) and limits of quatitiation (LOQ) will be reported. *Keywords: Biomonitoring, Chemical analysis, Fish.*

MCGOLDRICK, D.J.[1], GEWURTZ, S.B.[1], CLARK, M.G.[1], KEIR, M.J.[1], MALECKI, M.M.[1], GLEDHILL, M.[2], SEKELA, M.[2], SYRGIANNIS, J.[3], EVANS, M.S.[4], ARMELLIN, A.[5], POMEROY, J.[6], WALTHO, J.[1], KONEFAL-HERRGESELL, M.[1], and BACKUS, S.M.[1], [1]Environment Canada, Ontario Freshwater Quality Monitoring, Burlington, ON, L7R 4A6; [2]Pacific and Yukon Fresh Water Quality Monitoring, Vancouver, BC; [3]Prairie and Northern Fresh Water Quality Monitoring, Regina, SK; [4]Aquatic Ecosystem Protection Research Division, Saskatoon, SK; [5]Quebec Fresh Water Quality Monitoring, Montreal, QC; [6]Atlantic Fresh Water Quality Monitoring, Dartmouth, NS. **Status and trends of PBDEs and other brominated flame retardants in Canadian fish.**

Beginning in 2006, spatial and temporal trends of polybrominated diphenyl ethers (PBDEs) and other brominated flame retardants in top predatory fish were examined from 19 water bodies across Canada. For PBDEs, concentrations of three major homologue groups (tetra-, penta-, and hexa-BDEs) were higher in Great Lakes fish compared to the other lakes analyzed. The Canadian Federal Environmental Quality

Guideline for the penta-homologue was exceeded in 70% of the fish. However, there were no guideline exceedances for other congeners. Where sufficient data exists to allow for trend analysis, levels of PBDEs in fish are declining by and average of ~5% per annum. In general, lower brominated congeners (e.g. BDE47), were positively correlated with bio-physical parameters (length, weight, age, lipid, and stable isotopes of C and N) while the relationships of higher brominated congeners (e.g. BDE183) to these same parameters were not consistent. This suggests that bioaccumulation of the higher congeners may be affected by biotransformation to lower congeners within the fish. A subset of the fish were screened for other non-PBDE flame retardants and tetrabromoethylcyclohexane (TBECH), hexachlorotricyclotridecadiene (DMPA), hexabromocyclododecane (HBCD), and bis(2-ethyl-1-hexyl)tetrabromophthalate) (BEHTBP) were regularly detected. *Keywords: Fish, Flame retardants, Biomonitoring, Contaminants.*

MCINTYRE, P.B.[1], ALLAN, J.D.[2], SMITH, S.D.P.[2], HALPERN, B.[3], BOYER, G.L.[4], BUCHSBAUM, A.[5], BURTON, A.[2], CAMPBELL, L.M.[6], CHADDERTON, L.[7], CIBOROWSKI, J.J.[8], DORAN, P.[7], EDER, T.[9], INFANTE, D.[10], JOHNSON, L.B.[11], LODGE, D.[12], READ, J.[13], RUTHERFORD, E.S.[14], SOWA, S.[7], STEINMAN, A.D.[15], and JOSEPH, C.[2], [1]Center for Limnology, University of Wisconsin, Madison, WI, 53706; [2]School of Natural Resources & Environment, University of Michigan, Ann Arbor, MI, 48109; [3]National Center for Ecological Analysis and Synthesis, Santa Barbara, CA, 93101; [4]College of Environmental Science and Forestry, State University of New York, Syracuse, NY, 13210; [5]National Wildlife Federation, Ann Arbor, MI, 48104; [6]Dept. of Biology, Queens University, Kingston, ON; [7]The Nature Conservancy, Lansing, MI, 48906; [8]Dept. of Biological Sciences, University of Windsor, Windsor, ON; [9]Great Lakes Commission, Ann Arbor, MI, 48104; [10]Dept. of Fisheries and Wildlife, Michigan State University, E. Lansing, MI, 48824; [11]Natural Resources Research Institute, University of Minnesota, Duluth, MN, 55811; [12]Dept. of Biological Sciences, University of Notre Dame, South Bend, IN, 46556; [13]Michigan Sea Grant, Ann Arbor, MI, 48109; [14]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 48104; [15]Annis Water Resources Institute, Grand Valley State University, Muskegon, MI, 49441. **Project GLEAM: Cumulative Mapping of Stressors Across the Great Lakes.**

The Great Lakes are subject to a multitude of environmental threats, or stressors, whose impacts vary spatially and across habitat types. The goals of the Great Lakes Environmental Assessment and Mapping Project (GLEAM) are to map the intensity of individual stressors across the Great Lakes, weight them by expected ecological impact, and combine them into a cumulative impact map. Here, we merge the results of an expert opinion assessment of impact weights with maps of 50 stressors representing every major category of threats to the Great Lakes. Synthesizing this information yields a map of cumulative human impact at 1 km2 resolution. We will discuss the broad spatial patterns identified by this approach, as well as the assumptions and choices involved in moving from stressor-specific to cumulative impact analyses. The GLEAM cumulative impact map represents not only a comprehensive, spatially-explicit assessment encompassing all five lakes, but also can be rescaled to focus upon regions of special interest. When

properly interpreted, it offers a new perspective for prioritizing management, restoration, and conservation activities, and sets the stage for analysis of threats to important services derived from the Great Lakes. *Keywords: Environmental effects, Spatial analysis, Spatial distribution.*

MCKAY, R.M.[1], BEALL, B.F.N.[1], OYSERMAN, B.O.[1], SCHULTZ, M.S.[1], BULLERJAHN, G.S.[1], and WOITYRA, W.C.[2], [1]Department of Biological Sciences, Bowling Green State University, Bowling Green, OH, 43403; [2]USCGC Neah Bay (WTGB 105), 1055 E 9th Street, Cleveland, OH, 44114. **Credible Data Collection in the Great Lakes by the US Coast Guard.**

One approach to address the declining role of government in environmental monitoring is the use of ships of opportunity to collect data. Here we describe a partnership with the US Coast Guard Cutter *Neah Bay* (WTGB-105) that has allowed us to overcome logistical obstacles to sampling the Great Lakes during winter. To promote collection of data in compliance with Ohio's Credible Data Law, crew members were enrolled in a BGSU general education science course and received training in water sampling. In some ways, this approach parallels the successful community-based monitoring programs that have arisen in recent decades. Although led by volunteers, water quality data produced by these efforts are routinely of high quality, reflecting the role of these volunteers as stakeholders in the community. Likewise, while assigned to *Neah Bay*, the Great Lakes serve as "home" to the crew members. By coupling the monitoring program with a course in which they learned about the many challenges faced by the Great Lakes, they too became invested in the project and are helping to address the void in our understanding of the winter ecosystem in Lake Erie. Further, by seeking certification under Ohio's Credible Data Program, data collected can be used by state agencies to help guide management and policy decisions. *Keywords: Monitoring, Ice, Lake Erie.*

MCLEAN, K.A.[1], STONE, M.[1], SMITH, R.E.H.[1], and DROPPO, I.G.[2], [1]University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1; [2]Canadian Centre for Inland Waters, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Erodibility and Transport Behavior of *Dreissenid* Mussel Deposits in the Nearshore Zone.**

Dreissenid mussels have altered particle transport dynamics in the near shore environment of the Great Lakes by intercepting, retaining and recycling suspended solids that were previously exported to the offshore environment. Particulate materials filtered from the water column by *dreissenids* are subsequently released as either feces or pseudofeces. Accordingly, this bio-transformation process alters the nature (grain size distribution, settling velocity and density) and transport properties (critical shear stress for erosion, erosion rates and bed stability) of particulate matter excreted by mussels. While knowledge of the transport characteristics of this material is required to refine particle transport dynamics and energy flow models in the Great Lakes, few studies have been conducted to directly quantify these processes. An annular flume was used to determine the critical shear stress for erosion, erosion rates and bed stability of *dreissenid* biodeposits. Materials studied in the flume consisted of 1) a combination of biodeposits and surface sediments collected from *dreissenid* beds and 2) biodeposits harvested in a weir box with *dreissenids*. The results show that erosion characteristics and sediment transport properties were strongly influenced by bed age and the presence of mussels. *Keywords: Dreissena, Biotransformation, Sediment transport.*

MCNAUGHT, A.S.[1], MCDONALD, E.A.[1], LARSON, D.L.[1], and ROSEMAN, E.F.[2], [1]Central Michigan Univesity, Department of Biology, Mount Pleasant, MI, 48859; [2]Great Lakes Science Center, Ann Arbor, MI, 48105. **Habitat Use by Larval Fish in the Detroit and St. Clair Rivers.**

Recent investigations of fish habitat along the Huron-Erie Corridor have revealed renewed spawning activity by several important species, however, little is known about early life history requirements in this system. We surveyed potential nursery habitats in the lower Detroit River weekly between May and July 2007 and in the St. Clair River Delta between May and July 2010. Larval fish were sampled with light traps and a 0.5-m conical net. We measured a wide range of abiotic and biotic parameters to distinguish habitats. Nursery areas varied in their connectivity to the main channel and had distinct macrophyte assemblages and substrate types but similar temperatures. Larval fish diversity was highest in the main channel, but most larvae were newly hatched. Both early and late stage larvae were present in nursery areas. Yellow perch and bluegill were common in soft-sediment nursery areas, whereas round gobies dominated hard-sediment nursery areas. Our data confirm that nursery areas are conducive to the development and survival of larval fish and show that species composition depends on substrate type and proximity to the main channel. *Keywords: Fish, Larval fish, Habitats, Connecting channel.*

MENSINGER, A.F. and LYNCH, M.P., Biology Department, Univerisity of Minnesota Duluth, Duluth, MN, 55812. **Site Fidelity and Movement of the Round Goby in the Duluth-Superior Harbor.**

The round goby, *Neogobius melanostomus*, is an invasive fish which has become a major component of the Laurentian Great Lakes ecosystem since its introduction in 1990. We currently are assessing its movement, site fidelity, and growth in the Duluth-Superior Harbor. Our initial studies indicated a maximal range expansion of less than 1 km per year. A current tag and recapture study confirms high site fidelity with minimal seasonal or yearly movement. Fish were captured biweekly using minnow traps located every 25 meters along a 550 meter stretch of the Duluth-Superior Harbor shoreline. A total of 1,328 tagged gobies, representing 419 individuals were recaptured during the ice-free months from July 2009 to August 2010. Net movement between captures exhibited a leptokurtic distribution centered at the site of original capture with 88% of the recaptured gobies showing no net movement and a maximum recorded movement of 475 meters. Instantaneous growth rates varied significantly between seasons, gender, and initial

length with the greatest growth exhibited by small males in midsummer.
Keywords: Invasive species, Round goby, Fish behavior.

MILLER, D.H.[1], TIETGE, J.E.[2], MCMASTER, M.E.[3], MUNKITTRICK, K.R.[4], XIA, X.[5], and ANKLEY, G.T.[2], [1]U.S. EPA, Mid-Continent Ecology Division, 9311 Groh Rd., Grosse Ile, MI, 48138, USA; [2]U.S. EPA, Mid-Continent Ecology Division, 6201 Congdon Blvd., Duluth, MN, 55804, USA; [3]Environment Canada, Ecosystem Health Assessment, 867 Lakeshore Rd., Burlington, ON, L7R 4A6, Canada; [4]Department of Biology, University of New Brunswick, 100 Tucker Park Road, Saint John, NB, E2L 4L5, Canada; [5]Computer Sciences Corporation, 9311 Groh Rd., Grosse Ile, MI, 48138, USA. **Assessment of Population Status for a White Sucker (*Catostomus commersoni*) Population Exposed to Bleached Kraft Pulp Mill Effluent.**

A predictive model was developed to translate changes in fecundity and age structure of a breeding population of white sucker (*Catostomus commersoni*) collected in the field to alterations in population growth rate. Application of this density dependent population projection model requires only a life table for the organism of interest, a measure of carrying capacity for the given population, and estimation of the effect of stressors on vital rates. Individual-level responses of fish exposed to pulp mill effluent at a study site in Jackfish Bay, Lake Superior, were used to demonstrate the model's capability to project alterations in population status. A white sucker population occurring at carrying capacity and subsequently exposed to pulp mill effluent equivalent to the exposure period of 1988-1994 would be expected to exhibit a 34 to 51% annual decrease in recruitment during the first 5 years following exposure, and reach an equilibrium population size of 71 % of carrying capacity. The Jackfish Bay study site contains monitoring data for biochemical endpoints of interest that could be combined with population modeling to extrapolate the construct demonstrated at the Jackfish Bay study site to other white sucker populations at sites that are less data rich. This abstract does not necessarily reflect U.S. EPA Policy. *Keywords: Populations, Risk assessment, Toxic substances.*

MILLIE, D.[1], FAHNENSTIEL, G.L.[2], and WECKMAN, G.[3], [1]Florida Institute of Oceanography, Univ. South Florida, St. Petersburg, Fl; [2]Lake Michigan Field Station/GLERL/NOAA, 1431 Beach St, Muskegon, MI, 49441; [3]Dept. Industrial and Systems Engineering, Ohio Univ., Athens, OH. **An 'enviro-informatic' assessment of Saginaw Bay phytoplankton: characterization and modeling of Microcystis.**

Saginaw Bay is a productive extension of Lake Huron, with a long history of anthropogenic perturbation. Recent NOAA-sponsored research initiatives (Invasive Zebra Mussels: 1990-1996 & Oceans & Human Health: 2003-2005) have provided comprehensive abiotic/biotic data concerning the impacts of mussel recruitment on Saginaw Bay's water quality and the compositional diversity and toxicity of phytoplankton, respectively. Here, computationally-intensive statistical approaches (e.g. non-metric multi-dimensional scaling, artificial neural networks, non-parametric

regression) are used to 1) characterize the abundance dynamics of the toxic cyanobacterium, Microcystis, within the context of the overall phytoplankton assemblage; 2) delineate key endogenous factors regulating (holistic) phytoplankton patterns; and 3) develop models for visualizing and predicting Microcystis abundance in relation to dynamic environmental constraints. Such information is intended to 'fuel' regional-scale modeling efforts, particularly the development and/or parameterization of models for integration into a 'next generation' Great Lakes HAB bulletin.
Keywords: Harmful algal blooms, Algae, Nutrients.

MINOR, E.C.[1], ZIGAH, P.K.[2], and WERNE, J.P.[1], [1]Large Lakes Observatory and Dept of Chem & Biochem., University of Minnesota Duluth, Duluth, MN, 55812; [2]Water Resources Science Program and Large Lakes Observatory, University of Minnesota Duluth, Duluth, MN, 55812. **Radiocarbon Evidence that Mesozooplankton Biomass in Lake Superior Incorporates Mainly Fresh Autochthonous Organic Matter.**

Lake food webs can be supported by organic carbon from recent local primary productivity and by organic carbon subsidies from neighboring (i.e., terrestrial) ecosystems or past in situ primary productivity. The importance of these subsidies to respiration and biomass production is a current topic of debate. These subsidies may play a significant role in determining the fate of organic carbon and in the ability of an ecosystem to sustain upper trophic levels, including those contributing to recreational and commercial fisheries. While some studies have reported that terrigenous particulate organic carbon (POC) supports disproportionately high zooplankton production (up to ~ 48%), others have suggested that live phytoplankton sustain most zooplankton production in aquatic ecosystems. In this study we apply natural abundance radiocarbon and stable isotope (C, N) analyses to show that Lake Superior mesozooplankton selectively incorporate recently-fixed, locally-produced (autochthonous) organic carbon even though other reduced carbon sources are available food options. Thus, any strong temporal or spatial organic carbon subsidy to lake heterotrophy appears constrained to the microbial loop or to respiration at intermediate trophic levels, and does not support the higher trophic levels of the food web. *Keywords: Biogeochemistry, Radiocarbon, Carbon cycle, Stable isotopes, Lake Superior.*

MISHRA, S., KUHANECK, R.M., PHILIPS, M., BISTA, D., ARMENIO, P., CHAFFIN, J., HECKATHORN, S.A., and BRIDGEMAN, T.B., Dept. of Environmental Sciences and Lake Erie Center, University of Toledo, Toledo, OH, 43606.
Environmental controls on growth and lipid content of the abundant bloom-forming diatom, *Aulacoseira granulata*: implications for algal blooms, food quality, and biofuel production.

Aulacoseira granulata is a common diatom in western Lake Erie, where it often blooms during early/mid-summer and can be, at times, the western basin's most-abundant alga and primary producer. *A. granulata* can accumulate lipids to high levels, which affects the quality of *A. granulata* for grazers and makes it potentially useful in production of oil-based biofuels. We investigated the role of environmental factors (nutrients, temperature, light, pH) in controlling growth and total lipid content of *A. granulata*, with both experiments and field monitoring. Growth of *A. granulata* was more-strongly influenced by N (urea>NO3 or NH4NO3) and Si, than P and C, and was optimal at 28C, pH 9, and 50 micromol/m^2/s PAR. Lipid content ranged from 10-25% of dry mass in the lake and from 25-45% in the lab, making this species among the most oil-rich of algae. Total lipids were affected by temperature and increased with decreasing N and Si, but were little influenced by P. In multi-species lab cultures, *A. granulata* was often out-competed by green algae, unless temperature, light, and N were maintained at low levels which slowed growth. Thus, environmental conditions that optimize growth in *A. granulata* typically decrease lipids for biofuel and may alter the food quality of this species. *Keywords: Phytoplankton, Diatoms, Biofuel, Algae.*

MISHRA, V.[1] and CHERKAUER, K.A.[2], [1]Civil and Environmental Engineering, University of Washington, Seattle, WA, 98195; [2]Agricultural and Biological Engineering, Purdue University, West Lafayette, IN, 47907. **Large-scale climate variability: Implications to small lakes in the Great Lakes Region.**

The landscape of the Great Lakes Region is dominated by the presence of thousands of small lakes and wetland systems. However, analysis of regional scale impacts for the small inland lakes remains a challenge due to lack of observations and a modeling framework for regional (multi-state) scales. We integrated a physically based one-dimensional lake model, and a methodology to parameterize small lakes regionally into a large-scale land surface model to understand the roles of large scale climate variability on the open water budget, temperature, and ice cover dynamics for small lakes in the Great Lakes region. With this tool we tried to address the questions: (1) How do large scale climate variability and climate teleconnections affect the water balance, thermal and ice cover dynamics of small lakes in the Great Lakes Region? (2) How sensitive are lakes to climatic extremes related to the water cycle (e.g. drought and floods) and thermal dynamics (e.g. water temperature and ice cover), and (3) What are the potential ecological implications of projected increases in the frequency and intensity of extreme climate years? Variability in climate and lake conditions were assessed with respect to local climate extremes and global climate teleconnections
Keywords: Hydrologic cycle, Climate variability, Drought, Great Lakes basin.

MISSAGHI, S., LIUKKONEN, B., HONDZO, M., BLICKENDERFER, M., TERRY, K., CHAPMAN, J., and PRESNAIL, M., University of Minnesota - SAFL, 2 Third Ave. SE, Minneapolis, MN, 55414. **Evaluating the relationship of climate change, lake hydrodynamic, shoreline vegetations, and bank erosion. Part I: project design, implementations, and data analysis.**

Aquatic systems, particularly large morphologically complex lakes, are sensitive to hydrodynamic changes such as water level fluctuations. Climate change can increase hydromodification and impact lake water quality and shoreline vegetation. There is a strong link between water level regimes and shoreline vegetation dynamics. Plants respond differently to varying water levels. This project investigated the relationship between climate change, shoreline plant survival, lake hydrodynamics, sediment nutrient flux, and water quality (Part I). A second goal is to provide a practical recommendation for future shoreline restorations and management based on our findings (Part II). Four experimental basins were planted (2010) with 8 plant species typically used in shoreline stabilization projects and were then subjected to changing water levels. Climate change scenarios and resulting water level changes were modeled using a hydrodynamic stormwater modeling software (XPSWMM) and a three-dimensional coupled hydrodynamic and ecological lake model (ELCOM-CAEDYM). Plant growth, water levels and water flow, water and sediment chemistry, and light were monitored. We will discuss modeling setup and configurations and present modeling results, plant survival and growth and water and sediment chemistry analyses. *Keywords: Climate change, Shore protection, Littoral zone.*

MISSAGHI, S. and HONDZO, M., University of Minnesota - SAFL, 2 Third Ave. SE, Minneapolis, MN, 55414. **Evaluation and application of a three-dimensional ecological model in a morphologically complex lake.**

Morphologically complex lakes need three-dimensional (3D) hydrodynamics and ecological models to accurately simulate their temporal and spatial dynamics. The basic hydrodynamic and ecological processes of a lake could be adequately reflected by one-dimensional (1D) numerical simulation models. However, accurate and robust 3D models are needed to capture inter and intra seasonal biogeochemical changes that shape the dynamic of these complex natural systems. We applied a 3D coupled hydrodynamic (ELCOM) and ecological (CAEDYM) model that was configured to simulate temperature, velocities, total phosphorus, nitrogen, pH, dissolved oxygen, organic carbon, and one algae group. The period of 4/1-10/1 (2000) was used for calibration and 4/1-10/1 (2005) was used for corroboration. We will discuss model setup, configuration, and results. The model was able to accurately capture the spatial and temporal biogeochemistry variations including the short duration variations. Results show that the lake hydrodynamic and ecological processes are susceptible to mixing due to inflow and wind variabilities over the seasonal stratification. An example of an ecological application of the model will be presented where coolwater fish habitat was examined under two climate scenarios by 1 and 3 dimensional analysis. *Keywords: Model studies, Lake management, Biogeochemistry.*

MITCHELL, T.[1] and SMITH, E.R.[2], [1]Environment Canada, 4905 Dufferin St., Toronto, ON, M3H 5T4; [2]US Environmental Protection Agency, 77 W. Jackson Blvd, Chicago, IL, 60604. **The Great Lakes Binational Toxic Strategy (GLBTS): 13 Years Later - Attributes, Limitations, and the Future.**

The Great Lakes Binational Toxics Strategy was created to achieve and report on reductions of the "dirty dozen" toxic chemicals within the Great Lakes Ecosystem. After

13 years, many of 17 binational challenge goals set out in the original Strategy have been achieved. Much has been learned from this unique process, and these lessons will provide a blueprint for moving forward to address reductions of current and future binational chemicals of concern in the Great Lakes. In setting new priorities for research, monitoring, surveillance and chemical management actions in the Great Lakes Basin, current assessments of the Great Lakes Water Quality Agreement have confirmed the need to move from static lists of priority substances to a more dynamic approach that considers changing environmental conditions and knowledge gained over time. This presentation will describe what we have learned from the GLBTS, what has worked well, and what could be improved upon, in order to inform future binational and bilateral work to address substances for action in the Great Lakes. *Keywords: Toxic substances, Binational action, Chemicals Management.*

MOORE, S.A.[1], YULE, D.L.[2], EBENER, M.P.[3], and CLARAMUNT, R.M.[4], [1]Grand Portage Band of Chippewa, 27 Store Rd., Grand Portage, MN, 55605, United States; [2]USGS - Lake Superior Biological Station, 2800 Lake Shore Dr., Ashland, WI, 54806, United States; [3]Chiipewa Ottawa Resource Authority, 179 W. Three Mile Rd., Sault Ste. Marie, MI, 49783, United States; [4]MDNRE - Charlevoix Fisheries Research Station, 96 Grant Street, Charlevoix, MI, 49720, United States. **In search of Albus, a morphometric analysis to determine the status of historic forms of cisco.**

Rehabilitating native Great Lakes forage fish species like cisco to areas where they have been extirpated has become a high priority for fisheries managers in the Great Lakes. Koelz (1929) sampled coregonines in the Great Lakes between 1917 and 1925 and provided a rich and valuable description of their diversity. Koelz (1929) used meristic metrics like scale counts and body measurements do describe three cisco forms including the C. artedi, C. albus, and C. manitoulinus. The goal of this study was to determine whether some of those historic forms of cisco were still present. The objectives were 1) to apply modern analytical methods (discriminant function analysis) to Koelz's (1929) data set to confirm his findings that his data set provides evidence of three cisco forms (i.e., C. artedi, C. albus, and C. manitoulinus), 2) use whole-body morphometric techniques to compare shapes of contemporary cisco collected from Great Lakes sites to determine the number of unique forms we can identify, and 3) determine if contemporary forms are consistent with historic forms. Analysis of images of cisco was used to identify shape differences from spawning aggregations and compared with those found in Koelz 1927. Evidence of a form similar in shape to Coregonus albus was found in Lake Michigan.
Keywords: Fish management, Cisco restoration, Biodiversity, Morphometrics, Lake Superior.

MOORE, Z.[1], AUSTIN, J.A.[2], and GREEN, P.A.[3], [1]UM Duluth, Duluth, MN, 55812; [2]Large Lakes Observatory, UM Duluth, Duluth, MN, 55812; [3]Isle Royale National Park, 800 East Lakeshore Drive, Houghton, MI, 49931. **Tracing a ballast water release in the Duluth/Superior Harbor using fluorescent dye.**

As part of a National Park Service and United States Geological Survey experiment to develop better strategies for ballast water treatment, we studied near field concentrations of fluorescent dye-tagged ballast water following the pump out of ballast water from the M/V Indiana Harbor in May 2010. A fluorescent dye (Rhodamine WT) was added and mixed into the ballast tank and released from the ship. The release event was tracked using a device that monitored depth, position, temperature, and fluorescence. The water was released through two different pathways; primarily through exhaust ports on the keel of the boat, and secondarily through ports just below the waterline on the side of the boat. Water released at the surface mixed with the harbor water and diluted rapidly. The water that was released through the keel ports sank to the bottom of the harbor and stayed at near full concentration for several hours after release. This was due to the fact that the ballast water was considerably cooler, and hence denser, than the ambient harbor water, and did not mix. This suggest that under certain circumstances, future studies of ballast water dispersion could be performed using temperature, rather than fluorescent dye, as a tracer of ballast water pathways over short time scales. *Keywords: Ballast, Estuaries, Water currents.*

MORRICE, J.A., TREBITZ, A.S., KELLY, J.R., SIERSZEN, M.E., COTTER, A.M., and HOLLENHORST, T.P., USEPA Mid-Continent Ecology Division, 6201 Congdon Blvd., Duluth, MN, 55804. **Hydrologic factors determining linkages of Great Lakes coastal wetlands to watershed and lake.**

Water can enter Great Lakes coastal wetlands (CWs) from both watershed and offshore sources. Identifying the relative contribution of these potential sources, and the spatial scale at which sources are influenced by human activities, are critical steps in wetland protection. We developed a hydrology-based classification scheme for CWs for the purpose of identifying dominant hydrologic influences and water sources. Classes were determined through analysis of data quantifying hydrologic linkages to lake (seiche) and watershed (watershed area, tributary discharge) in 57 CWs distributed along the U.S. shoreline of the Great Lakes. CWs were partitioned into 4 classes of hydrology that were predicted to differ in sources of water. Source water predictions were tested by comparing Chloride (Cl) concentrations in wetland, lake, and tributary waters of the CWs in each class. Results confirmed that classification based on quantitative hydrology data was successful in identifying groups of wetlands with similar water sources. Correlations between wetland Cl, an indicator of anthropogenic disturbance, and agricultural land cover suggest that differences among classes in water sources resulted in differences in the scale at which CWs were connected to and influenced by landscapes. This abstract does not necessarily reflect USEPA policy. *Keywords: Watersheds, Hydrodynamics, Coastal processes.*

MORRIS, J.R., USGS Ohio Water Science Center, 6480 Doubletree Avenue, Columbus, OH, 43229. **USGS Beach-Health Investigations throughout the Great Lakes.**

Scientists at the U.S. Geological Survey (USGS) have been working on research related to beach health for over a decade. The overall mission of this work is to provide science-based information and methods that will allow beach managers to more accurately make beach closure and advisory decisions, understand the sources and physical processes affecting beach contaminants, and identify how to apply research to mitigate fecal contamination, restore beaches, and protect the public. Current work consists of four science elements: (1) expanding the use of and improving real-time assessments, (2) testing and applying methods for pathogens and source-tracking markers, (3) understanding coastal processes that influence indicator and pathogen concentrations, including identifying physical and biological factors that contribute to recreational water quality along extended shoreline areas, and (4) improving Great Lakes-wide beach-data analysis, interpretation, and communication. Funding for USGS beach research comes from a variety of sources, and collaborations with local and state agencies are considered a key to the success of applying research to address real problems and provide relevant solutions to USGS partners. *Keywords: Microbiological studies, Nearshore, Monitoring, Beach health, Human health.*

MOSES, S.K.[1] and HUDSON, M.J.[2], [1]Great Lakes Indian Fish & Wildlife Commission, 72682 Maple St. P.O. Box 9, Odanah, WI, 54861, US; [2]Bad River Watershed Association, 101 W. Main St. Suite #353, P.O. Box 875, Ashland, WI, 54806, US.
Current levels and temporal trends of legacy contaminants and emerging chemicals of concern in the Lake Superior ecosystem.

The Great Lakes Water Quality Agreement requires Lakewide Management Plans (LaMPs) to identify and reduce critical chemicals in each Great Lake. In Lake Superior, LaMP agencies have identified nine Persistent, Bioaccumulative and Toxic (PBT) chemicals slated for zero discharge from anthropogenic sources in the lake's basin by 2020. In addition, other critical chemicals and chemicals of interest are monitored and tracked over time for management considerations as needed. Periodically, levels (i.e. concentrations) of these chemicals in the Lake Superior ecosystem (such as water, fish and sediment) are compared to yardsticks established by jurisdictions around the lake as a way to evaluate management program efficacy and identify potential new concerns. Current levels and temporal trend data for Lake Superior zero discharge and other chemicals of interest will be presented in various media such as fish, water, sediment, and wildlife. Where jurisdictional yardsticks are available, levels will be compared for an assessment of impaired uses. New and emerging chemicals of concern will be discussed and, where appropriate, data from Lake Superior media will be compared to chemical data from the other Great Lakes. *Keywords: Environmental contaminants, Lake Superior.*

MOU, X., LU, X., and HEATH, R.T., Department of Biological Sciences, Kent State University, Kent, OH, 44242, USA. **Metagenomes of Microcystin-degrading Bacteria in Lake Erie.**

Microcystin concentrations during summer cyanobacterial blooms in Lake Erie often reach dangerously high at 10-20 □g/L, threatening the health of organisms depending on the lake water. Heterotrophic bacteria are thought a potential agent for decomposing algal toxins. To identify genes and taxa that may involved in microcystin degradation in Lake Erie, we sequenced metagenomes of Lake Erie bacterioplankton with and without amendments with microcystin. A total of 816,435 unique sequences were obtained with average sequence read length of 385 bp. Pair-wise bootstrapping analysis identified over 80 COG groups and 40 KEGG pathways overrepresented in the microcystin-amended (MC) metagenomes relative to the controls (CTRL). Overrepresented functions mainly included cellular metabolisms of carbohydrate and amino acids, energy production and conservation, signal transduction and cell motility. Taxonomic affiliation at the order level revealed that MC had significantly more of Methylophilales of the Betaproteobacteria (48% vs. 5%) and Xanthomonadales of the Gammaproteobacteria (11% vs. 2%) but less Actinomycetales (1% vs. 14%) than the CTRL. The Burkholderiales of Betaproteobacteria were abundant in both metagenomes (15-18%). Our results suggest that microcystin may be preferentially sensed and degraded by certain lake bacteria. *Keywords: Microbiological studies.*

MOUW, C.B.[1], MCKINLEY, G.A.[1], CHEN, H.[1], EFFLER, S.W.[2], O'DONNELL, D.M.[2], PERKINS, M.G.[2], STRAIT, C.M.[2], and STERNER, R.W.[3], [1]University of Wisconsin-Madison, 1225 W. Dayton Street, Madison, WI, 53706; [2]Upstate Freshwater Institute, Syracuse, NY, 13214; [3]Univeristy of Minnesota, St. Paul, MN, 55108. **Evaluation and Optimization of Bio-Optical Inversion Algorithms for Remote Sensing of Lake Superior's Optical and Biogeochemical Properties.**

Basic understanding of Lake Superior's carbon budget and temporal/spatial variability of optical and biogeochemical parameters is lacking. The elusive knowledge persists due to the scarcity of observations. Remote sensing offers an excellent platform to observe the entire lake. However, remote sensing products of the lake have been slow to develop due to the independency of optical constituents (case 2 waters), domination of colored dissolved organic matter, and complex atmosphere of the region. We have analyzed the available optical observations of the lake and compared their variability to the NASA bio-Optical Marine Algorithm Data set (NOMAD) global optical dataset from which many of the existing inversion algorithms have been developed from or validated with. Existing inversion algorithms have been evaluated on the Lake Superior optical data and tuned for optimal performance. The tuned inversion algorithms were applied to SeaWiFS and MODIS imagery and validated with lake-wide chlorophyll concentration observations. Spatial/temporal trends of the satellite retrieved biogeochemical parameters were analyzed in the context of the physical dynamics of the lake. *Keywords: Lake Superior, Optics, Remote sensing.*

MOYNIHAN, M.A.[1], KANNAPPAN, V.[2], KASHIAN, D.[2], STOW, C.A.[3], and GRONEWOLD, A.D.[3], [1]Cornell University, Ithaca, NY; [2]Wayne State University, Detroit, MI; [3]Great Lakes Environmental Research Laboratory, National Oceanic and Atmospheric Administration, Ann Arbor, MI. ***E. coli* and *Enterococci* Concentrations in Great Lakes Beaches: Implications of Small Scale Sampling Variability on Perceived Threats to Human Health.**

Water quality assessments at Great Lakes beaches are based on the relationship between fecal indicator bacteria (FIB) concentrations and water quality standards. USEPA-recommended protocols for collecting and analyzing samples, however, are variable, as are the range of numeric limits on FIB concentrations throughout the Great Lakes. In addition, conventional analysis procedures have intrinsic variability that is often not explicitly acknowledged when assessing water quality and waterborne pathogenic threats to human health. In this study, we implement a Bayesian statistical analysis procedure to quantify uncertainty in FIB measurements of both *E. coli* and *Enterococci* using two different analysis procedures to explore variability between methods and their relationship to water quality standards. We focus our study on small-scale spatial and temporal variability in water quality samples in beaches of Lake Huron's Saginaw Bay. Our results suggest that different approaches to quantifying uncertainty (including Bayesian analysis procedures) lead to different management decisions, and provide a basis for future modifications to existing water quality standards in an effort to provide a more consistent approach to protecting human health. *Keywords: Water quality, Microbiological studies, Monitoring.*

MUELLER, S.K., BRANSTRATOR, D.K., and HRABIK, T.R., University of Minnesota Duluth, Duluth, MN, 55812. **Phosphorus regeneration by *Mysis relicta* in the deep chlorophyll layer of Lake Superior.**

Despite a phosphorus limited system and recent declines in total phosphorus, phytoplankton in Lake Superior's deep chlorophyll layer (DCL) maintain lower C:P ratios than their epilimnetic counterparts, suggesting possible underlying mechanisms that produce higher phosphorus availability at these depths (25-50m). *Mysis relicta* may provide a link in the pelagic food web by both translocating nutrients during diel vertical migration and regenerating nutrients while feeding in the DCL. Migrating *Mysis* collected from Lake Superior were incubated shipboard and excretion of soluble reactive phosphorus (SRP) was measured. Mysis excreted phosphorus at an average rate of .015 µg SRP mg^{-1} h^{-1}. Maximum daily SRP contribution to the DCL, calculated as the product of regeneration rate, time spent in the DCL (8 hours), and peak biomass in the DCL (10.48 mg m^{-3}), is 1.26 µg SRP day^{-1}. This is similar to estimates of *Mysis* regeneration in Lake Michigan where they provide up to 10% of SRP demand by primary producers. However, Lake Superior is less productive than Lake Michigan, and Mysis are therefore likely to provide an even greater proportion of the phosphorus demand.
Keywords: Zooplankton, Phosphorus, Lake Superior.

MUIR, A.M.[1], KRUEGER, C.K.[1], ZIMMERMAN, M.S.[2], BRONTE, C.R.[3], QUINLAN, H.R.[4], and GLASE, J.[5], [1]Great Lakes Fishery Commission, 2100 Commonwealth Blvd., Suite 100, Ann Arbor, MI, 48105; [2]Washington Department of Fish and Wildlife, 600 Capitol Way N., Olympia, WA, 98501; [3]U.S. Fish and Wildlife Service, , Green Bay Fish and Wildlife Conservation Office, 2661 Scott Tower Dr., New Franken, WI, 54229; [4]U.S. Fish and Wildlife Service, Ashland Fish and Wildlife Conservation Office, 2800 Lake Shore Dr., East, Ashland, WI, 54806; [5]National Park Service, 800 East Lakeshore Dr., Houghton, MI, 49931. **Phenotypic diversity of Lake Trout at Isle Royale, Lake Superior.**

Multiple lake trout Salvelinus namaycush morphs existed in the Great Lakes; however, much of that diversity was lost. Previous research demonstrated shallow-water lean, mid-water humpers, and deepwater siscowet populations at Isle Royale, Lake Superior. As part of an ongoing study of lake trout diversity, we revisited these populations. Research objectives were to: 1) identify lake trout morphs at Isle Royale and quantify differentiation among them; 2) determine associations between body shape and other phenotypic traits; and 3) compare group membership assessed by experienced observers to those predicted by statistical models. Geometric morphometric methods were used to define body shape. A clustering of body shape indicated the presence of multiple groups that broadly conformed to lean, humper, and siscowet morphs. Groups were weakly defined and high misclassification suggested weak differentiation compared to large Canadian lakes. Head, belly, and peduncle morphology contributed significantly to variation. Difficulty in discerning morphs suggests that intermediate forms may exist or that introgression has occurred. Overfishing, sea lamprey predation, and stocking may have contributed to introgression; alternatively, discrete morphs may never have existed and variation could be due to ongoing differentiation of lake trout. *Keywords: Lake Superior, Morphology, Lake trout, Rehabilitation.*

MUKHERJEE, M., SCHLAIS, M.J., MCKAY, R.M., and BULLERJAHN, G.S., Bowling Green State University, Department of Biological Sciences, Bowling Green, OH, 43403. **Identification and Enumeration of Lake Superior Nitrifying Archaea by Fluorescence in situ Hybridization.**

Nitrification is a major process controlling the nitrogen cycle in world waters in which ammonia is converted into nitrate. Over the past 100 years, Lake Superior has seen a large increase in nitrate, causing a stoichiometric imbalance of N:P in the lake, the reason for which is largely unexplained. Previously it was assumed that bacteria (e.g., *Nitrosomonas* and *Nitrobacter*) are responsible for this process. Over the past decade, researchers have discovered different groups of nitrifying archaea, specifically Crenarchaeota/Thaumarcheota Groups I.1a, and I.1b, in marine and freshwater environments. In this study we have identified specific groups of nitrifying Archaea in Lake Superior harboring the *amoA* genes, encoding a subunit of the ammonia monooxygenase enzyme. From the 16S sequences obtained from enrichment cultures of Lake Superior water samples, we have developed labeled CARD-FISH probes specific to

these groups of nitrifyers, allowing their enumeration in the Lake Superior water column throughout from spring to fall 2010. *Keywords: Lake Superior, Archaea, Nitrification.*

MULUGETA, S.G., GREENE, K.E., SPACHT, D.E., CLARK, E.J., JONES, G.E., and MAURO, S.A., Mercyhurst College, 501 East 38th Street, Erie, PA, 16546. **The active ingredient in anti-depressants decreases bacterial and viral content in a freshwater aquatic ecosystem.**

Fluoxetine is the active ingredient in anti-depressant drugs and has been shown to accumulate in recreational waters at levels that have the potential to negatively impact aquatic organisms including fish, algae, and crustaceans. However, the impact of fluoxetine on aquatic microbes remain poorly understand. In this study, we examined how fluoxetine influences overall and specific bacterial and viral levels in the recreational waters of Presque Isle State Park in Erie, Pennsylvania. Our results demonstrate that fluoxetine can decrease total bacterial and viral levels in these waters. Further, our studies comparing different bacterial types suggests that fluoxetine cytotoxicity is not uniform, indicating that fluoxetine presence impacts microbial aquatic ecosystems in a complex way that should be further examined. *Keywords: Microbiological studies, Chemical analysis, Lake Erie.*

MUNAWAR, M.[1], MUNAWAR, I.F.[2], and FITZPATRICK, M.[1], [1]Fisheries & Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [2]Plankton Canada, Burlington, ON. **Microbial - planktonic food webs of the Great Lakes: comparing stressed vs. unstressed ecosystems.**

Our lab has undertaken comprehensive assessments of the microbial - planktonic food web across the Laurentian Great Lakes over the past 20 years. In this paper, we examine the structure and function of the lower food web across a gradient of trophic conditions. Our methodology includes detailed microscopic analysis of the microbial and planktonic communities combined with radioisotope measurements of primary and secondary productivity. In ultra-oligotrophic and pristine Lake Superior, the structure of the organic carbon pool was found to be dominated by autotrophs. By comparison, in the hyper-eutrophic Bay of Quinte, Lake Ontario, heterotrophs made very significant contributions to the carbon pool and in some cases were even dominant. The relative importance of autotrophs vs. heterotrophs appears to be a good indicator of ecosystem stress. We discuss the implications of variations in the structure and function of microbial - planktonic food webs as it relates to the health of a variety of lakes. Our study emphasizes the need for assessing lower trophic levels, especially the microbial loop, in order to fully understand the linkages across trophic levels. *Keywords: Environmental health, Organic carbon, Plankton.*

MUNAWAR, M.[1], NIBLOCK, H.[1], FITZPATRICK, M.[1], EL-SHAARAWI, A.[2], LORIMER, J.[1], ROZON, R.[1], and KLING, H.[1], [1]Fisheries & Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [2]Environment Canada, Burlington, ON; [3]Algal Taxonomy & Ecology, Winnipeg, MB. **Intensive field and laboratory testing of the Fluoroprobe for assessing photosynthetic communities under eutrophic and oligotrophic conditions.**

The Fluoroprobe is being used globally for the assessment of chlorophyll a and spectral classification of photosynthetic organisms. A critical evaluation of the Fluoroprobe data compared to standard laboratory methods is warranted to assess the suitability of the instrument. Consequently, we compared chlorophyll a measured in situ from the probe with chlorophyll a measured in vitro (cold acetone pigment extraction and spectrophotometric analysis). We also compared the spectral groupings of the photosynthetic community by Fluoroprobe with taxonomic identification and enumeration of phytoplankton by standard Utermohl microscopic analysis. Intensive spatial and temporal sampling was conducted in Lake Ontario, Bay of Quinte and Hamilton Harbour across habitats ranging from ultra-oligotrophic to hyper-eutrophic. The chlorophyll a data was subjected to statistical analysis including linear regressions and paired sample t tests. In Hamilton Harbour, Fluoroprobe generated spectral classes were compared against species composition. The results suggest that Fluoroprobe data was not compatible with the taxonomic analysis. Consequently, ground truthing of the Fluoroprobe against standard taxonomic analysis is essential before spectral classes could be considered as reliable indicators of community composition for research and monitoring. *Keywords: Algae, Technologies, Species composition, Chlorophyll, Monitoring.*

MUNOZ UCROS, J. and HICKS, R.E., University of Minnesota, Duluth, MN, 55812.
Comparing the Distributions of Planktonic *Archaea* in Lakes Superior and Malawi.

Microorganisms in the domain Archaea are now known to be much more diverse and abundant than what was once thought, but little is known about their distributions in great lakes. This project compares the spatial distribution of Archaea in two oligotrophic lakes, Lake Superior in North America and Lake Malawi, a tropical African great lake. Previous work in Lake Superior suggests that planktonic archaeal abundance decreases in warm surface water after the thermocline forms, but their distribution has not yet been explored in Lake Malawi. We are estimating the abundances of total and ammonia-oxidizing Archaea at different depths across both of these lakes using quantitative PCR targeting the 16S rRNA and archaeal amoA genes. We also hope to estimate the relative activity of these microbial groups in these lakes by comparing RNA/DNA ratios using qPCR and reverse transcriptase qPCR. These results should help resolve whether the distributions of planktonic Archaea are similar in temperate and tropical great lakes of similar trophic status. *Keywords: Comparison studies, Archaea, Lake Malawi, Lake Superior.*

MUNSON, B.H.[1], MARTZ, M.A.[2], and SHIMEK, S.[1], [1]120 Bohannon Hall, 1207 Ordean Court, Duluth, MN, 55812; [2]Tom Ridge Environmental Center, 301 Peninsula Drive, Suite 3, Erie, PA, 16505. **Effective Scientist-Teacher Collaborations through COSEE Great Lakes.**

Scientist-teacher collaborations can benefit both participants (Tanner, 2000). Mutually beneficial scientist-teacher collaborations were one of the goals of the Centers for Ocean Sciences Education Excellence (COSEE) Great Lakes program. This five-year project, funded by NSF and NOAA, used carousel work group methods in a concluding Summit meeting to explore participant perceptions regarding scientist-teacher collaborations. Scientists and teachers described general and personal benefits from teacher-scientist collaborations such as diversifying teaching and communication strategies and greater understanding of the other's working context. "Immersion experiences" were identified as a 'best practice' for collaboration. Funding and time were identified as major obstacles to collaboration, but strategies were recommended for overcoming these obstacles and potentially institutionalizing teacher-scientist collaborations. The interaction dynamics, impacts, and recommendations from the Summit participants were consistent with the research of Caton (2000), Drayton and Falk (2006), Nelson (2005), Rahm et al. (2003), Tanner (2000), Wormstead et al. (2002). However, the importance of immersion experiences was a unique recommendation.
Keywords: Education, Outreach.

MURRY, B.A.[1], COOPER, M.J.[2], and UZARSKI, D.G.[1], [1]Central Michigan Univ Biological Station, Institute for Great Lakes Research, Mt. Pleasant, MI, 48859; [2]University of Notre Dame, Department of Biological Sciences, Notre Dame, IN, 46556.
Beyond Mean Monthly Water Levels: the Effects of Water Level Magnitude, Timing, and Rate of Change on Great Lake Coastal Wetland Fish Assemblages.

The Natural Flow Regime concept was originally devised to compartmentalize and describe the many ways in which stream flow influences water quality, physical habitat, and biota in lotic systems. The same concept can be applied to lentic systems and can provide greater insight than typical mean monthly gauge data. We investigated changes in total fish abundance, species richness, and evenness relative to changes in the magnitude, timing, and rate of change of lake levels in the inner and outer bulrush zones of Great Lake coastal wetlands. Approximately 90% of Great Lakes fishes utilize coastal wetlands during their life cycle and water level dynamics could influence habitat suitability. Components of the water level regime can also affect fish by acting as cues initiating changes in life history. For example, the spring equinox and the summer solstice are important photoperiod cues that may interact with the water level regime to influence migrations and spawning. Thus, we hypothesized that individual components of the water level regime will be correlated with the abundance, richness and evenness of fish in Great Lake coastal wetlands. We found that the rate of water level change, as well as minimum and maximum spring water levels all influenced fish species richness and

abundance in Great Lake coastal wetlands. *Keywords: Water level fluctuations, Fish, Wetlands.*

MYERS, J.T.[1], JONES, M.L.[1], YULE, D.L.[2], and STOCKWELL, J.D.[3], [1]Quantitative Fisheries Center, Department of Fisheries and Wildlife, Michigan State University, 13 Natural Resources Building, East Lansing, MI, 48824; [2]U.S. Geological Survey, Great Lakes Science Center, Lake Superior Biological Station, 2800 Lakeshore Drive, Ashland, WI, 54806; [3]Gulf of Maine Research Institute, 350 Commercial Street, Portland, ME, 04101. **Evaluating Effects of Temperature on Lake Superior Cisco Recruitment.**

Recent analyses suggest variable recruitment of cisco *Coregonus artedi* is a natural characteristic of the species in Lake Superior, yet little is known about what causes the large differences in observed annual recruitment. Prevailing climate conditions play an important role in driving ecological processes and evidence from marine systems suggests relatively small changes in the mortality or growth rates of larval fish can produce large fluctuations in observed recruitment. We have constructed a mechanistic simulation model to explore the potential for small differences in spring temperature to cause large differences in the survival of age-0 cisco in Thunder Bay (Lake Superior). Daily estimates of surface and sub-surface water temperatures from 1995-2006 were used to drive model simulations and determine the spatiotemporal overlap between cisco and their associated prey (i.e. copepod nauplii) and predators (i.e. rainbow smelt *Osmerus mordax*). Simulated recruitment was a function of the growth and survival of age-0 cisco during each respective year. The magnitude of simulated recruitment was compared to empirical estimates of recruitment from hydroacoustic and midwater trawl surveys conducted in Thunder Bay. *Keywords: Lake Superior, Cisco, Recruitment, Ecosystem modeling.*

NEGUS, M.T.[1] and BERGSTEDT, R.A.[2], [1]Minnesota Department of Natural Resources, 5351 North Shore Drive, Duluth, MN, 55804; [2]USGS, Great Lakes Science Center, Hammond Bay Biological Station, 11188 Ray Rd, Millersburg, MI, 49759. **Rates of Intra-Peritoneal Temperature Change in Lake Trout Implanted with Archival Tags.**

Archival tags that are surgically implanted in fish can provide temperature and depth information in the natural environment. However, internal body temperatures recorded by implanted tags lag behind external temperatures when a thermal gradient is encountered, as the body temperature shifts toward that of the ambient water. The rate of temperature change can be approximated by Newton's law of cooling, which states that the rate of temperature change of an object is proportional to the difference between its own temperature and the ambient temperature. The rate of intra-peritoneal temperature change was examined in lake trout *Salvelinus namaycush* ranging from about 800g to 2,200g, by moving fish to both warmer and cooler water temperatures. Internal temperatures of these fish took about 20 to 40 minutes to approach ambient temperatures. This time lag provides ample opportunity for fish to make brief forays into water of suboptimal temperature with minimal change in intra-peritoneal temperature, thus enabling behavioral thermoregulation. The relationship between the rate of temperature change and body weight varies depending on body shape, and the location where measurements are taken, so rates from laterally compressed fish, or very differently shaped fish will differ from those measured in salmonids. *Keywords: Fish tagging, Data storage and retrieval, Habitats.*

NETT, J.H.G.[1], CAMPBELL, T.B.[1], MANDRAK, N.E.[2], and TIEGS, S.D.[1], [1]Oakland University, 2200 N. Squirrel Road, Rochester, MI, 48309; [2]Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **A Comparison of Sampling Methods for Detecting Round Gobies (*Neogobius melanostomus*) in Streams.**

The recent invasion of the round goby into tributaries of the Laurentian Great Lakes poses concerns for native fish communities and the functioning of stream ecosystems. Developing sensitive detection methods and identifying invaded sites are prerequisites towards the implementation of effective management strategies in streams, where standard methods for detection are lacking. In this study, the CPUE (gobies/minute) efficiency of three gear types, two active (triple-pass electrofishing and seining) and one passive (minnow traps), were compared for 34 stream sites in southeastern Michigan, with each gear type applied to each site. Probabilities of detection were determined for each gear type as number of sites where gobies were detected with a particular gear divided by total number of sites where gobies were detected. Overall CPUEs were 0.078, 0.137, and 0.716 gobies/minute for traps, electrofishing, and seining, respectively, with seining being significantly more efficient ($p < .001$). There was no significant difference, however, between CPUEs for electrofishing and traps ($p > 0.5$). Probabilities of detection were 0.50, 0.68, and 0.79 for traps, electrofishing, and seining, respectively. The results of this study should help tailor sampling protocols for the effective of detection round gobies in streams. *Keywords: Invasive species, Round goby, Fish management.*

NEWSTED, J.L.[1] and GIESY, J.P.[2], [1]Cardno Entrix, 4295 Okemos Road, Suite 101, Okemos, MI, 48864; [2]University of Saskatchewan, of Biomedical and Veterinary Biosciences and Toxicology Centre, Saskatoon, SK, S7N 5B3. **Toxicological Perspectives of Perfluorooctane Sulfonate (PFOS) to Mink and Otters.**

Perfluorooctane sulfonate (PFOS) have been widely used in commerce and until this last decade, little was known about their environmental fate and effects. The assessment of possible effects has been hampered by a lack of toxicological data in wildlife species. However, the Great Lakes Initiative (GLI) can derive protective values for sentinel wildlife using surrogate species. In this study, a benchmark dose was determined using data from a multigenerational rat study. Bioaccumulation and biomagnification factors were used to extrapolate toxic doses water value (WV) for mink 4.5 ng PFOS and 6.1 ng PFOS/L. The mammalian wildlife value was determined to be 5.3 ng PFOS/L. While the GLI approach focuses on food web extrapolations to water, the literature indicates that sediments may also be an important vector of PFOS to aquatic organisms and upper trophic level predators. As a result, the GLI may produce overly protective water values. A simple food web model was used to estimate the significance of water and sediments as sources of PFOS to mink. The results from this analysis indicated that the sediments are a source of PFOS to mink and should be taken into consideration when setting water values. Finally, these wildlife values are discussed relative to current PFOS concentrations measured in Great Lakes. *Keywords: Risk assessment, Mink, Perfluorooctane sulfonate, Water quality.*

NGHIEM, S.V.[1] and LESHKEVICH, G.[2], [1]JIFRESSE-UCLA / JPL-CalTech, 4800 Oak Grove Drive, MS 300-235, Pasadena, CA, 91109; [2]NOAA/Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108. **Advancing a Satellite Synthetic Aperture Radar (SAR) Ice Classification Algorithm.**

This presentation describes an advance in our freshwater ice classification algorithm using RADARSAT-2 polarimetric and ENVISAT ASAR AP (dual co-polarization) data. The high resolution of satellite synthetic aperture radar (SAR) measurements with its all-weather, day/night sensing capabilities make it well suited to map and monitor Great Lakes ice cover. Using our library of calibrated polarimetric SAR ice backscatter signatures, an algorithm was developed to classify and map major Great Lakes ice types. Although initial algorithm validation showed that the algorithm correctly classified ice types in the library, open water was often misclassified owing to the ambiguity encountered in single polarization data due to variations in wind speed and wind direction over water. RADARSAT-2 polarimetric and ENVISAT dual polarized data collected in conjunction with in situ measurements reveal that multi-polarization backscatter data is better to map ice types and open water without this ambiguity. Ice / water masks were developed for both small and large incidence angles encountered in the data after which the library of signatures can be applied to classify the ice types. *Keywords: Remote sensing, Satellite technology, Ice.*

NGOCHERA, M.[1], MACUIANE, M.[2], HECKY, R.E.[2], and GUILDFORD, S.J.[2], [1]Malawi Fisheries Department and University Wisconsin Milwaukee, Salima, Malawi; [2]Large Lakes Observatory, University Minnesota Duluth, Duluth, MN, 55812. **Defining patterns of phytoplankton composition and abundance in Lake Malawi.**

Phytoplankton composition was characterized using an in situ spectral fluorometer (FluoroProbe) along a transect from northern Lake Malawi to the southern region of the lake and into Lake Malombe a small shallow riverine lake on the Shire River outflow from Lake Malawi. In situ chlorophyll concentrations in the northern and central regions of Lake Malawi were less than 2.0 micrograms per litre with the maximum concentration between 20 to 40 m. Southern sites had shallow maximum chlorophyll at 5 m with maximum concentrations of 10 micrograms per litre. "Diatoms" dominated at all sites however "chlorophytes" and "cyanobacteria" were also observed in the more southern sites. Riverine stations in Lake Malombe were similar to Lake Malawi but sites away from the river plume were dramatically different with total chlorophyll concentrations of 40 micrograms per litre comprised primarily of "cyanobacteria". In situ spectral fluorometry allowed the rapid assessment of spatial patterns of phytoplankton abundance and composition in this large tropical lake and will be a useful monitoring technique. *Keywords: Cyanobacteria, Fluoroprobe, Chlorophyll, Africa, Algae, Diatoms.*

NIEMI, G.J., University of Minnesota-Duluth, 5013 Miller Trunk Highway, Duluth, MN, 55811. **The influence of landscapes on Great Lakes coastal ecosystems.**

Landscapes surrounding the Great Lakes coastal region have varying influence on the biological communities of the nearshore zone. The signal of influence from the shoreline to the open lake also varies but depends on characteristics such as hydrology, the physical structure, and composition of the coastal area. The Great Lakes Environmental Indicators (GLEI) project quantified over 200 data layers (pressure indicators) for the coastal area and watersheds of the United States Great Lakes coast. These data were used to identify a human disturbance gradient, primarily driven by landscape characteristics of the coastal region. A random, stratified design of over 200 wetland systems were sampled across this gradient to assess the biological state of amphibian, bird, diatom, fish, invertebrate, and plant communities. The exploration of relationships among these communities and the human disturbance gradient revealed that agricultural activity and urban-residential land uses had the largest effects on the biological communities of the nearshore zone. Point sources effects were limited and confined to the industrial areas of the coastal region. These results and landscape considerations for the entire Great Lakes coastal region will be summarized, especially in the context of future research activity. *Keywords: Watersheds, Coastal ecosystems, Ecosystem health.*

NORTH, R.L.[1], WINTER, J.[2], and DILLON, P.J.[1], [1]Department of Chemistry, Trent University, 1600 West Bank Drive, Peterborough, ON, K9J 7B8; [2]Environmental Monitoring and Reporting Branch, Ontario Ministry of the Environment, 125 Resources Rd, Toronto, ON, M9P 3V6. **Phosphorus Bioavailability to Phytoplankton in Lake Simcoe.**

In Lake Simcoe, the largest inland lake in southern Ontario, we found that phosphorus (P) is the limiting nutrient to algal growth. Currently, there is a lot of effort going into controlling the P inputs to the lake, and although total P loads and in-lake concentrations are known, the bioavailability of this P is still unknown. Seasonal (including under-ice) and spatial surveys were conducted from 2008 to 2011 to determine the P status of phytoplankton communities. P bioavailability was examined using the different forms of P, as well as physiological indicators of nutrient status including alkaline phosphatase activity (APA), P-debt, stoichiometric ratios of particulate nutrients (N:P, C:P) and P addition photosynthetic efficiency experiments. We determined that the majority of lake stations were P deficient, and the deepest stations exhibited the most P limitation. Seasonally, the phytoplankton appeared most P deficient in the early stratified

summer period. There appears to be a lack of correlation between P concentrations and indicators of P limitation which may be related to the relationship between different forms of P. *Keywords: Phytoplankton, Lake Simcoe, Phosphorus.*

NORTH, R.P. and LIVINGSTONE, D.M., Eawag, Swiss Federal Institute of Aquatic Science and Technology, Department of Water Resources and Drinking Water, Uberlandstrasse 133, Dubendorf, 8600, Switzerland. **1D Modeling of Climate Change Impacts on Hypolimnetic Oxygen Depletion.**

The influence of climate change on bottom-water hypoxia in Swiss lakes was investigated using long-term lake records and an existing 1D hypolimnetic oxygen depletion model. Combining modeling and empirical analysis can lead to a better understanding of how past changes in lake forcing factors affected hypolimnetic oxygen consumption. Missed measurements and irregular sampling intervals in the data were replaced by interpolation. Cubic spline and linear interpolation were compared to determine the optimal method for each lake variable and domain (temporal and spatial). The resulting data sets with regular measurement intervals could then be examined using different data analysis techniques. Given a spring oxygen value (initial concentration), lake topography, and areal (sediment) and volumetric (water column) oxygen consumption rates, the model determines the hypolimnetic oxygen profile prior to fall turnover. Validating the model with measured profiles provides an estimate of summer oxygen consumption rates. Both modeling and empirical analysis were applied to several Swiss lakes whose time-series of water column measurement profiles date as far back as 1936. Insights gained by understanding past lake behavior will lead to improved quantification of future changes in the frequency and duration of lake hypoxia events. *Keywords: Mathematical models, Hypoxia, Climate change, Oxygen.*

O'DONNELL, D.M.[1], STRAIT, C.M.[1], EFFLER, S.W.[1], LEE, Z.P.[2], and GREB, S.R.[3], [1]Upstate Freshwater Institute, PO Box 506, Syracuse, NY, 13214; [2]Mississippi State University, 1103 Balch Blvd, Stennis Space Center, MS, 39529; [3]Wisconsin Department of Natural Resources, 2801 Progress Rd., Madison, WI, 53716. **Optical Characterizations and Pursuit of Closure across the Gradients of Green Bay and Near-shore Lake Michigan.**

In situ measurements of inherent and apparent optical properties were made September 17-19, 2010 within Green Bay and near-shore Lake Michigan to advance the characterization of the underwater and emergent light fields of these waters and to support related IOP-based model development and testing. Measurements were made using a combined profiling package of ac-s and BB9 meters (WETLabs). Remote sensing reflectance and diffuse attenuation coefficient was measured using a HyperPro II (Satlantic). Spectral and vertical patterns of absorption, scattering and backscattering are reported. Spatial patterns of optical characteristics are presented and relate drivers are considered. Both analytical and semi-analytical optics models are evaluated for closure. *Keywords: Lake Michigan, Green Bay, Remote sensing.*

O'REILLY, C.M.[1], HOHOFF, T.[2], and MBEMBA, W.[3], [1]Bard College, Biology Program, Annandale, NY, 12504; [2]Department of Biology, Winona State University, Winona, MN, 55987; [3]Action Contre la Faim, Kinchasa, Democratic Republic of Congo.
Interacting effects of climate change and El Nino on recent warming patterns in Lake Tanganyika, East Africa.

Interannual variation in recent warming trends in Lake Tanganyika, East Africa, can be linked to El Nino Southern Oscillation (ENSO). Lake Tanganyika is a deep, permanently stratified lake, and mixing during the windy season is an important source of deep-water nutrients to the food web. Past work has indicated increased stratification and reduced mixing associated with rising air temperatures over the past century, leading to lower productivity. We compiled local meteorological data and collected limnological data from 1998 to 2007. Lake profiles showed a strong increase in stratification. Although there were no clear long-term patterns in average air temperature or wind speed on monthly scales, there were seasonal patterns, with particularly low wind speeds during ENSO years. These could contribute to a temporary reduction in heat loss, ultimately leading to a net increase in heat retention over time within the broader context of rising air temperatures. This suggests a step-wise response to current climate change rather than gradual, continuous change. Additionally, relationships between the Oceanic Nino Index and local meteorological variables indicate the potential for earlier identification of ENSO events by up to 6 months. Our results suggest that current climate changes reduce the resilience of the lake to ENSO events. *Keywords: Climate change, El Nino, Africa.*

OFFENBERG, J.H.[1], PILETIC, I.[1], LEWANDOWSKI, M.[1], KLEINDIENST, T.E.[1], DOCHERTY, K.S.[2], and JAOUI, M.[2], [1]109 T.W. Alexander Dr, U.S. Environmental Protection Agency - ORD / NERL, Research Triangle Park, NC, 27711; [2]Alion Science and Technology, Research Triangle Park, NC, 27709. **Contributions of Secondary Organic Aerosol to Particulate Matter Pollution in Cleveland Ohio during 2009 / 2010.**

A precursor specific, organic tracer-based method was used to estimate the secondary contributions of biogenic and anthropogenic precursor hydrocarbons to ambient organic carbon concentrations in PM2.5 during August 2009 and February 2010 in two downtown locations in Cleveland and one site adjacent to Chippewa Lake near Medina, Ohio. One hundred eighty ambient PM2.5 samples were collected on a 24 hour schedule and analyzed for (1) secondary organic aerosol tracer compounds, (2) levoglucosan, a compound used as a tracer for biomass burning, and (3) organic and elemental carbon. For isoprene, α-pinene, β-caryophyllene, and toluene, the secondary contributions to ambient organic carbon concentrations were estimated using measured tracer concentrations and previously published, laboratory-determined mass fractions. Additionally, 180 parallel samples were collected for 14C analysis to determine the fraction of new carbon. The relative contributions of the four precursor hydrocarbons to the measured organic carbon concentration across the three locations as well as a comparison with the measure of the relative importance of carbon of petrogenic origin relative to 'new' carbon will be presented. *Keywords: Atmospheric circulation, Organic carbon, Organic compounds.*

OLKER, J.H.[1], SCHOFF, P.K.[1], and JOHNSON, R.D.[2], [1]Natural Resources Research Institute - University of MN Duluth, 5013 Miller Trunk Hwy, Duluth, MN, 55811; [2]EPA Mid-Continent Ecology Division, 6201 Congdon Boulevard, Duluth, MN, 55804.
Distribution of Testicular Oocytes within Male *Rana pipiens*.

Presence of egg cells in testicular tissue (testicular oocytes, TOs) may represent reproductive effects of great concern. TO presence and abundance has been used as an endpoint in assays for endocrine-disrupting substances in amphibian and fish. The lack of definitive protocols and variety of histopathological techniques used to evaluate TOs make it challenging to compare studies and species. We evaluated testicular oocyte distribution in wild metamorphic *Rana pipiens* (northern leopard frog) to assess the differences in TO presence and abundance across gonadal sections as well as between left and right testes. For 164 metamorphic *Rana pipiens* we identified and counted TOs in longitudinal 50 µm step-sections covering the entirety of both gonads. Number of TOs was compared for left versus right testes and middle versus outer sections per individual. We evaluated TO distribution across sections and difference in mean TOs per section using six sub-sampling regimes. When TOs were present, they were evenly distributed throughout the middle portion of the gonad, and between left and right gonad. Sub-sampling 10-25% of all sections predicted the overall mean TOs per section and specimen rank, suggesting that this time- and cost-saving methodology is effective for evaluating amphibian TOs. *Keywords: Methods development, Amphibians, Endocrine disruption.*

ONG, J.B.[1], LENTERS, J.D.[2], ZLOTNIK, V.A.[1], and JONES, S.L.[2], [1]Department of Earth and Atmospheric Sciences, University of Nebraska-Lincoln, Lincoln, NE, 68588; [2]School of Natural Resources, University of Nebraska-Lincoln, Lincoln, NE, 68583.
Variations in the energy, water, and salt balance of a saline lake in the semi-arid Sandhills region of western Nebraska (USA).

The Sandhills region of western Nebraska comprises the largest stabilized dune field in the western hemisphere. Although situated in a semi-arid climate, the sandy soils allow a significant fraction of the ambient precipitation to drain through and recharge the underlying Ogallala aquifer, which then seeps upward in interdunal depressions to form hundreds of lakes throughout the region. Where present, however, these lakes evaporate rapidly as a result of the warm, dry, sunny, and windy conditions. Many of the lakes, therefore, are highly saline, often supporting a diverse wetland ecosystem. A field study of one of these lakes was initiated in 2007 to examine the effects of climate variability on the energy, water, and salt balance of the lake. The lake is shallow (roughly 30 cm), but is observed to undergo significant variations in water level relative to its mean depth (e.g., almost completely drying up during some periods). Salinity values undergo similarly

large variations and are found to respond relatively rapidly to precipitation and evaporation events. Energy balance estimates of lake evaporation show summertime values (7-8 mm/day) that are well in excess of the mean precipitation rate. This suggests significant inputs from groundwater, and we estimate this net seepage rate as a residual of the lake water balance. *Keywords: Atmosphere-lake interaction, Saline lakes, Hydrologic budget.*

OPFER, S.E.[1], ARTHUR, C.D.[2], and LIPPIATT, S.M.[2], [1]NOAA Marine Debris Division, 240 W. Lake St., Unit C, Oak Harbor, OH, 43449; [2]NOAA Marine Debris Division, 1305 East-West Highway, Silver Spring, MD, 20910. **NOAA Protocols for Marine Debris Monitoring and Assessment in Coastal Surface Waters of the Great Lakes.**

The issue of marine debris was first recognized a half-century ago, yet until 2009 a comprehensive and standardized protocol for assessment of man-made persistent debris in coastal waters did not exist. Scientific monitoring of marine debris is necessary to understand distribution, abundance, movement, and impact of debris on regional, national, and global scales. In 2009 the NOAA Marine Debris Division developed standardized protocol for monitoring the abundance and density of debris in coastal surface waters. Information presented will include: 1. Background on how the protocol was developed, including research into other monitoring programs 2. Design of a net comparison study conducted in western Lake Erie in spring 2011 3. Initial results, including spatial distribution and debris density by material category, and future directions, including assessment of statistical rigor, sampling frequency, and ways in which data and methods will be shared with scientists and citizens interested in monitoring debris. This is the first study to compare nets using the NOAA protocol. The results of this project will allow for comparisons of debris types and amounts not only among the Great Lakes coastal habitats but across the United States. Results will also be made available to existing monitoring programs. *Keywords: Lake Erie, Debris, Monitoring, Coastal ecosystems.*

OSTER, R.J. and HICKS, R.E., University of Minnesota-Duluth, Dept of Biology, 1035 Kirby Dr., SSB 207, Duluth, MN, 55812. **Using Chemical and Microbiological Factors to Assess the Risk of Accelerated Corrosion in the Duluth-Superior Harbor.**

Accelerated corrosive loss of steel infrastructure in the Duluth-Superior Harbor (DSH) is a major local concern and both chemical and microbiological factors may be contributing to this loss. The concentration of ions known to cause corrosion such as chloride and sulfate have either decreased or remained constant from the 1970's to the 1990's. Alkalinity, thought to inhibit corrosion remained constant at 50-55 mg/L during this time. The Larson-Skold Index of corrosivity was calculated and decreased or remained constant during this period, indicating water chemistry by itself may not be the primary cause of corrosion in the DSH. A consortia of microorganisms including sulfate-reducing bacteria (SRB) and iron-oxidizing bacteria (FeOB) have been implicated in the dissolution of iron from steel surfaces at DSH. An evaluation of water chemistry and microbiology is important for the development of an assessment tool to determine the risk of this type of corrosion in the DSH and in other harbors within the Great Lakes. Preliminary quantitative PCR assays for both SRB and FeOB may indicate that the abundance of such microbes are greater at sites more affected by corrosion. The ability to estimate corrosive risk to steel structures will be essential for local governments and businesses who must manage costs for their replacement. *Keywords: Microbiological studies, Corrosion, Water quality, Chemical analysis.*

OSTERN, C.[1] and HLINA, P.[2], [1]Douglas County Land & Water Conservation Dept., 1313 Belknap St., Rm. 206, Superior, WI, 54880; [2]Lake Superior Research Institute - UWS, PO Box 2000, Superior, WI, 54880. **Remediation-to-Restoration ("R2R") at Hog Island, St. Louis River of Concern, Lake Superior - A Success Story and Model.**

The Hog Island site is located in the St. Louis River AOC at the western tip of Lake Superior. The site was one of the first to be remediated through the Great Lakes Legacy Act and is also one of the first R2R projects. On-going restoration is returning ecological function, structure, and diversity to this heavily contaminated portion of the harbor; addressing several beneficial use impairments. A blueprint for restoration, the draft Hog Island Ecological Restoration Master Plan, was developed following remediation and used to apply for grant funding for habitat restoration. 2011 will be the third and final year of grant-funded restoration work. In years one and two, riparian buffers were restored; unique habitat structures were installed; wild rice seeded; and invasive species eliminated via chemical-free methods then replaced with native emergent vegetation. Restoration activities were conducted by Douglas County, WI through a regional partnership with NOAA and the Great Lakes Commission; in collaboration with the Lake Superior Research Institute with more than a dozen students, two native plant restoration companies, and numerous state and federal agencies. The Hog Island R2R project serves as a model for other such projects in the Great Lakes. *Keywords: Ecological restoration, Lake Superior, Resource management.*

PAGANO, J.J.[2], CRIMMINS, B.S.[1], XIA, X.[1], MILLIGAN, M.S.[3], HOPKE, P.K.[1], and HOLSEN, T.M.[1], [1]Clarkson University, Potsdam, NY; [2]SUNY Oswego, Oswego, NY; [3]SUNY Fredonia, Fredonia, NY. **Non-PBDE Flame Retardants in Great Lakes Fish.**

The Great Lakes Fish Monitoring and Surveillance Program (GLFMSP) was recently tasked with exploring non-legacy contaminant distributions in the Great Lakes' top predators. Numerous studies have examined the distribution of polybrominated diphenyl ethers (PBDE) in various environmental matrices prompting the discontinued usage of the penta- and octa-PBDE mixtures in numerous countries and the remaining mixture (deca-PBDE) soon to be removed from the market place. Other halogenated flame retardant compounds, identified as potential replacements have been detected in the environment or identified in chemical screening exercises based on their production volume, persistence, bioaccumulative potential and toxicity. These include Dechlorane

Plus and its derivatives (Dechlorane 602-605), octabromo-1,3,3-trimethyl-1-phenylindan, 1,2-bis(2,4,6-tribromophenoxy)ethane, pentabromoethylbenzene, bis(2-ethyl-1-hexyl)tetrabromophthalate, 2-ethylhexyl-2,3,4,5-tetrabromobenzoate. As part of the GLFMSP we have screened Great Lakes' lake trout for these potential replacements to determine the spatial distribution and level of concern these PBDE replacements pose to the Great Lakes aquatic system. *Keywords: Environmental contaminants, Lake trout.*

PALONEN, K.E.[1], DE SOLLA, S.R.[1], and STRUGER, J.[2], [1]Wildlife and Landscape Sience Directorate, Environment Canada, Burlington, ON, L7R 4A6; [2]Water Science and Technology Directorate, Environment Canada, Burlington, ON, L7R 4A6. **Phenology of Amphibian Breeding in Relation to Pesticide Exposure in Ontario.**

Amphibians often are exposed to pesticides while breeding in agricultural landscapes, and the timing of breeding may affect their exposure. The phenology of amphibian lifestage (egg, tadpole, metamorph, adult) varies among frog species, as does their behaviours (calling, breeding, post-breeding). Our objective was to identify the relative exposure to pesticides for each lifestage and behaviour. Using frog calling intensities, time to hatch, and time to metamorphosis for eight frog species across Ontario, we estimated the lifestage and behavioural phenologies. Data from Environment Canada's Pesticide Science Fund initiative in Ontario were used to quantify temporal changes in concentrations of pesticides in surface waters. For American toads, leopard frogs and spring peepers, the pesticide concentrations generally increased throughout their three life stages, whereas for bullfrogs and green frogs exposure was highest during the egg stage. Generally the concentrations peaked post breeding for early breeders and during breeding for late breeders, and thus pesticide residues were highest during the tadpole or metaphorph stage for late breeders. Data relating pesticide exposure with amphibian lifestage and breeding behaviour is important for assessing risk, and for designing appropriate exposure regimes for toxicological studies.
Keywords: Amphibians, Pesticides, Monitoring.

PANYUSHKINA, I.P. and LEAVITT, S.W., Lab. of Tree-Ring Research, University of Arizona, Tucson, AZ, 85721. **Dieback Patterns of Ancient Spruce in the Great Lakes Region between ca. 14,000 and 10,000 cal yr BP.**

We studied wood preserved in ancient forest beds and as tree relics across Lake Michigan shorelines and along the southern edge of Lake Superior. Multiple tree-ring chronologies and stand ecology records from several sites were developed. Calendar ages of the tree-ring records derived from radiocarbon wiggles generally clustered into three periods: 13,300-13,800 cal yr BP, 11,200-11,400 cal yr BP and 10,900-11,600 cal yr BP. Our collective data suggest that flooding and rising water table were among the major factors killing spruce stands around the Great Lakes during the last re-advance (Two Creek stadial) and transition between the Younger Dryas to the Early Holocene. Several abrupt and persistent flooding events during deglaciation triggered spruce dieback over 25 to 35-year periods. Tree-ring variance of the post-glacial stands showed similarities

with modern tree-ring growth and stand ecology of spruce invading habitats adjacent to Hudson Bay. We speculate whether modern spruce stands from the Hudson Bay region may soon face the same hazardous impact of excessive wetness produced by intensive permafrost thawing and/or sea-level rise. *Keywords: Great Lakes basin, Ancient forests, Deglaciation, Dendrochronology, Climate change, Paleoclimate.*

PASCOE, T.[1], MCDANIEL, T.V.[1], BINDING, C.E.[1], YERUBANDI, R.[1], WATSON, S.B.[1], GOU, J.[1], and KLING, H.[2], [1]Environment Canada, PO Box 5050, Burlington, ON, L7R 4A6; [2]Algal Taxonomy and Ecology Inc., 13 Laval Dr., Winnipeg, MB, R3T 2X8.
Multiple approaches to environmental monitoring in Lake of the Woods: Linking water and sediment quality to the macro-benthic community.

Concerns regarding excess nutrient loading and cyanobacteria blooms in Lake of the Woods (LoW) prompted the formation of Environment Canada's Lake of the Woods Science Initiative in 2008. As part of a larger program to assess and remediate deteriorating water quality in Lake Winnipeg, this initiative sought to identify and fill knowledge and data gaps in nutrient levels and cycling in LoW, and the subsequent impacts on the aquatic environment. In partnership with stakeholders at all levels, Environment Canada has worked over the last three years to engage scientific expertise working at multiple scales in a coordinated effort. The talk will provide an overview of environment Canada's efforts to characterize the physical and chemical environment of Lake of the Woods with an emphasis on macro benthos. We examined spatial patterns in the benthic macro-invertebrate community of the lake, using Environment Canada's CABIN program, in relation to physical and chemical characteristics of the water and sediments and contrasted this with patterns of phytoplankton blooms.
Keywords: Biomonitoring, Lake Winnipeg, Nutrients.

PELLER, J.R. and ARGYILAN, E.P., Indiana University Northwest, 3400 Broadway, Gary, IN, 46408. **Awareness, Education and Action: Students and Educators Taking Ownership of the Lake Michigan Watershed through Integrated Curriculum.**

Northwest Indiana represents the southern coast of Lake Michigan, and Indiana citizens have a unique responsibility to manage and protect this portion of the lake and its adjoining watershed. As part of the citizen and government responsibility, education on the Lake Michigan watershed and its current challenges should be incorporated into lesson plans of local high school science classes. The education on local watershed problems will lead to greater personal responsibility, improved public protection for the environment and an enhanced interest in science. These young people will have an advantage in a future workforce dedicated to sound environmental practices. This new program, funded by the Indiana Lake Michigan Coastal Grants, will be conducted during summer 2011 and led by IU Northwest science professors. Several high school science teachers will participate in learning more about Indiana's Lake Michigan watershed through workshops, lectures, field trips and research experiences, guided by the local scientific community; they will then be required to incorporate watershed topics into their curriculum by developing specific Lake Michigan watershed curriculum units. The integration of Lake Michigan watershed science into high school curricula will lead to greater awareness and protection of local natural resources. *Keywords: Education, Lake Michigan, Water quality.*

PENNUTO, C.M.[1], FISCHER, A.[2], BASILIKO, C.[3], and MAKAREWICZ, J.[4], [1]Biology Dept. & Great Lakes Center, Buffalo State College, Buffalo, NY, 14222; [2]Chemistry Dept., Buffalo State College, Buffalo, NY, 14222; [3]Great Lakes Center, Buffalo State College, Buffalo, NY, 14222; [4]Dept. of Environmental Science & Biology, SUNY Brockport, Brockport, NY, 14420. **Round Goby Size and Abundance Correlates With Habitat in Nearshore Lake Ontario, NY.**

Round gobies (*Neogobius melanostomus*) occupy all the Great Lakes, their connecting waters, and many tributaries. Understanding their impacts on resident biota or ecosystem processes requires, among other things, data on their abundance. As part of the LONNS project, we assessed round goby size and abundance in nearshore Lake Ontario in conjunction with estimates of substrate composition, *Dreissena* abundance, size and biomass, and *Cladophora* biomass. Goby abundance and size were estimated using fixed quadrat video recordings. There was a distinct west-to-east decline in goby size (as TL), and this coincided with a decline in mussel mean size. Goby size was positively correlated with *Cladophora* biomass. Goby abundance was greatest when *Dreissena* abundance and biomass were high, but showed no correlation with mussel size or lake location. There was a significant negative correlation between goby abundance and *Cladophora* biomass, suggesting fewer, larger gobies inhabited algal beds. Gobies occurred on all substrate types (sand, bedrock, boulder, mussel beds), but were least abundant on sand and wave-swept bedrock substrates. Collectively, these data provide insights into the goby-mussel-*Cladophora* triad in Lake Ontario and establish a baseline estimate for future goby assessments. *Keywords: Mussels, Lake Ontario, Round goby.*

PEPPLER, M.C.[1] and RACHOL, C.M.[2], [1]8505 Research Way, Middleton, WI, 53562, US; [2]6520 Mercantile Way, Ste 5, Lansing, MI, 48911. **USGS Lake Management Plan Support: Web Mapping of Existing Lake Metadata.**

Through our activities within each of the Great Lakes Lake Management Plans (LaMPs), the USGS is uniquely positioned to assist with designing and implementing a GIS based Web Mapping Application (or LaMP WMA) that will integrate a variety of data (for example water quality measurement locations, fish population, and bathymetry). The LaMP WMA will allow for managers with little GIS capabilities to view the locations and extent of past and current data collection efforts and provide a basis for coordinating future activities within the basin. Currently available data, more recent datasets, as well as data that are already available in the form of national datasets will be used to populate the LaMP WMA. The LaMP WMA will serve as a tool through which administrators, scientists, and the public can gain access to program summary data without GIS expertise to help share information about data and increase collaboration.

The LaMP WMA is a pilot project in development for Lake Huron and Lake Michigan.
Keywords: Decision making, Web Mapping, GIS, Planning.

PEREZ-FUENTETAJA, A. and WUERSTLE, J., Biology Dept. and Great Lakes Center, SUNY - College at Buffalo, Buffalo, NY, 14222. **Feeding Preferences of a New Great Lakes Invader, *Hemimysis anomala*, the Bloody Red Shrimp.**

Hemimysis anomala is a recent invader in the Great Lakes region and is spreading within the lakes and their watersheds. Stomach contents of field collected organisms show an omnivorous diet that includes algae and zooplankton. To learn about prey size selection of *Hemimysis* we conducted an experiment that included two light environments, low light and complete darkness, presence or absence of algae, and three prey sizes of *Daphnia pulex*. Three *Hemimysis* predator sizes were used (small, medium, large), and they were allowed to feed for 6 h. after acclimation. All sizes of *Hemimysis* were able to feed on all sizes of *Daphnia* with a significant preference for small and medium sizes of prey. *Hemimysis* also consumed significantly more prey in complete darkness, although small (juvenile) *Hemimysis* also fed actively at low light. Presence of algae, despite being part of their diet, did not significantly affect feeding rates on zooplankton prey. These results contribute to our understanding of the feeding ecology of a new invader and its potential impact on nearshore zooplankton grazers.
Keywords: Exotic species, Hemimysis anomala, Invasive species, Feeding ecology, Zooplankton, Prey size selection.

PETERSEN, S., BADER, J., BERGQUIST, G., BOGUS, B., DOROBEK, A.C., and KOONCE, J.F., Department of Biology, Case Western Reserve University, Cleveland, OH, 44106. **Wetland Lab Module with a Civic Engagement Component: Pedagogical Challenges and Student Learning Gains.**

Utilizing the natural ecosystems of the Cleveland Metroparks for research in undergraduate laboratory courses offers excellent opportunities for civic engagement, but also poses unique pedagogical challenges. We report on the results of employing a new joint laboratory module with a civic engagement component in two existing ecology and aquatic biology laboratory courses. Students worked collaboratively to collect, analyze, and present data to assess the ecological integrity of the Lake Abram ecosystem, part of the Lake-to-Lake trail complex in the Big Creek Reservation of Cleveland Metroparks. Using pre- and post-module evaluations of student learning gains, course evaluations, peer assessments, grading rubrics, and instructor observations we assessed the effectiveness of the module in: (1) fostering awareness of wetland ecosystem degradation and management, (2) developing skills in identifying patterns and analyzing data, (3) working productively in collaborative groups, and (4) understanding the process of data-based decision making in a natural resource management setting. Although we found that students enjoyed the experience, performance indicators suggest we did not fully realize our learning outcomes. *Keywords: Environmental education, Wetlands.*

PETERSON, J., LOHSE-HANSON, C., and FISHER, H., Minnesota Pollution Control Agency, St. Paul, MN. **Open Burning Abatement in the Minnesota Portion of the Lake Superior Basin.**

The Zero Discharge Demonstration Program (ZDDP) is a plan to achieve zero release of nine designated persistent bioaccumulative toxic substances in the Lake Superior basin. Dioxin and mercury are some of the nine chemicals targeted in the ZDDP. Open burning of trash produces toxic chemicals such as dioxin and also distributes other toxic chemicals such as heavy metals into the environment. Open burning of trash is still a common practice among rural populations. As part of the Minnesota Pollution Control Agency's commitment to the ZDDP, an open burning abatement project was carried out in northeastern Minnesota that built on previous work done by the Western Lake Superior Sanitary District. The project was preceded by a statewide open burning practices survey in 2004 and followed by another statewide survey in 2010. The surveys indicate that while open burning dropped statewide between 2004 and 2010, the rate was lower in northeastern Minnesota in 2004 (i.e., 45% of rural Minnesotans statewide vs. 36% in NE MN) and dropped more than the statewide average in 2010 (i.e., 12% reduction statewide vs. 19% in NE MN). The results suggest that early work by WLSSD was effective in raising awareness and changing practices and the additional efforts between 2004 and 2010 increased the number of households that stopped burning. *Keywords: Toxic substances, Environmental contaminants, Lake Superior.*

PHANIKUMAR, M.S., SHEN, C., and NIU, J., Civil & Environmental Engineering, Michigan State University, East Lansing, MI, 48824. **Understanding Water Budgets in Great Lakes Watersheds Using an Efficient, Process-Based Distributed Hydrologic Model.**

To understand key hydrologic processes in the Great Lakes region and to quantify the nature and magnitude of fluxes in several watersheds, we used a new distributed hydrologic model PAWS (Process-based Adaptive Watershed Simulator, Shen and Phanikumar, Advances in Water Resources, 33(12), 2010). A comprehensive vegetation module was recently added to the original PAWS model by coupling the functionality of the Community Land Model (CLM version 4.0, National Center for Atmospheric Research) with the flow modules in PAWS. Here, we first describe the application of the (PAWS+CLM) model to watersheds in the Great Lakes region and present detailed comparisons with different types of data (stream flows, transient groundwater heads, soil moisture, soil temperature etc). We then use the models to compute annual average fluxes due to infiltration, evapotranspiration, surface runoff, sublimation, recharge, groundwater contribution to streams etc. as percent of precipitation and describe the inter-annual variability in the fluxes. This work provides new estimates of water budgets in Great Lakes watersheds and the results are expected to be useful in assessing the relative strengths of various process descriptions in physically-based hydrologic models.
Keywords: Watersheds, Hydrologic budget, Mathematical models.

PIERCE, L.[1], CRAWFORD, E.[2], PALSULE, V.[2], WILLEY, J.[2], FAISAL, M.[3], KIM, R.[3], and STEPIEN, C.A.[1], [1]Lake Erie Center and Dept. Environmental Sciences, University of Toledo, Toledo, OH, 43616; [2]George Isaac Cancer Research Center, University of Toledo Health Science Campus, Toledo, OH, 43614; [3]Department of Pathobiology and Diagnostic Investigation, Dept. of Veterinary Medicine, Michigan State Univ., East Lansing, MI, 48824. **A Rapid Genetic Test for the VHS Fish Virus and Viral Load from Laboratory Challenge Experiments.**

A unique and especially virulent strain (IVb) of viral hemorrhagic septicemia virus (VHSv) has outbroke since 2005 in the Great Lakes, killing many important fishes - including muskellunge and yellow perch. The virus poses extensive risks to fisheries, aquaculture, and baitfish industries. Cell culture, which is a weeks-long laborious process, is the only currently USDA-APHIS approved VHS diagnostic method. Our new molecular assay, Standardized Reverse Transcriptase Polymerase Chain Reaction (StaRT-PCR), is designed to greatly speed detection time (to hours) and increase accuracy - eliminating false negatives and false positives via a standardized mixture of internal standards (SMIS). We additionally are fine-tuning our test to uniquely identify among VHSv strains and to distinguish whether the virus is actively replicating (transmissible). We here evaluate our StaRT-PCR results on infected fish cell lines and immersion- and injection-challenged live fish experiments, in comparison with cell culture, plaque assay, and quantitative Real-Time (qRT) PCR diagnostic tests. Results to date show that StaRT-PCR is more accurate, with fewer false negatives. We also find that quantities of virus vary widely among infected individuals and do not significantly differ between symptomatic and asymptomatic laboratory fish. *Keywords: Fish diseases, Genetic test, Invasive species, Diagnostics, Fisheries, Aquaculture.*

PILLSBURY, R.W., University of Wisconsin, Oshkosh, 800 Algoma Blvd., Oshkosh, WI, 54901. **Fingerprinting Nuisance Cladophora Events: Can Associated Attached Algae Provide Management Tools?**

The nuisance alga Cladohora can form large, rotting, detached mats along shorelines. This is an increasing problem for homeowners and beach managers on the Great Lakes. During the summers of 2007-2009, composite samples of these mats were collected from various swimming beaches in Door county, Wisconsin (Lake Michigan, USA). All samples were preserved and examined under a light microscope to determine the composition and morphological characteristics of the filamentous algae. Relative abundances of attahced diatom species were also determined. We found that these "Cladophora mats" were often dominated by other filamentous genera. Algal mats from even nearby beaches (<3 Km) could be distinguished by Cladophora cell morphology, the relative abundance of other filamentous algae, and the associated epiphyte community. This unique combination of mat characteristics can persist for over a year and may enable the identification of the off shore sources of these beach-closing occurrences. This knowledge could broaden the management options for recreeational beaches.
Keywords: Management, Biomonitoring, Cladophora.

PILLSBURY, R.W.[1], THOMPSON, J.A.[2], and EDLUND, M.B.[3], [1]University of Wisconsin, Oshkosh, 800 Algoma Blvd., Oshkosh, WI, 54901; [2]U.S. Environmental Protection Agency, 6201 Congdon Blvd., Duluth, MN, 55804; [3]St. Croix Watershed Res. Stn., Marine on St. Croix, MN, 55423. **The History of the Nuisance Alga Didymosphenia geminata in Lake Superior: Should We be Concerned?**

Didymosphenia geminata is a single-celled diatom (alga) that has historically been found in relatively small numbers. It has been known for decades to existed in Lake Superior in relatively low densities. For reasons that are not clear, this alga has recently acted like an invasive species in many rivers of the world. Where once it was rare, D. geminata is now producing dense (> 3 cm thick), brown mats of slime covering all available substrata in many oligotrophic rivers worldwide. In 2008 and 2010 (2009 was not sampled) we identified extensive blooms of D. geminata along the north shore of Lake Superior. Although to some long-time residents of the north shore the high densities of D. geminata seem like a new phenomenon, the sparness of recent and historical records makes it difficult to draw any conclusions. We examine the documented occurances of D. geminata in Lake Superior and demonstrate the need for systematic monitoring of the near-shore algal community. *Keywords: Diatoms, Invasive species, Lake Superior.*

POOS, M., KOOPS, M.A., and MANDRAK, N.E., Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Science, Burlington, ON, L7R 4A6.
Evaluating the winners and the losers of round goby invasion into Great Lakes tributaries.

The secondary invasion of round goby (*Neogobius melanostomus*) from the Great Lakes into its tributaries represents a new threat to native lotic fishes. Previous research has shown that the impacts of round goby invasion may be particularly high for benthic congeners such as logperch and mottled sculpin. Here, we compared the diet and habitat use of nine benthic fishes pre- and post- round goby invasion using a before-after-control-impact (BACI) design. Samples were collected in 2010 along the invading front of round goby in the Sydenham River, Ontario, Canada and compared to samples taken in 2002 prior to round goby invasion. We compare catch-per-unit effort (CPUE), shifts in diet, as well as differences in both macro- and micro-habitat use. Using both univariate (e.g. ANOVAs and ANCOVAs) and multivariate analyses, we examine the magnitude of impacts of round goby invasion for the benthic fish community, outline the potential winners and losers, and discuss implications for the management of Great Lakes tributaries. *Keywords: Invasive species, Tributaries, Niches.*

POSTE, A.E.[1], HECKY, R.E.[2], and GUILDFORD, S.J.[2], [1]University of Waterloo, 200 University Ave. W., Waterloo, ON, N2L 3G1; [2]University of Minnesota-Duluth, 2205 E. 5th St., Duluth, MN, 55812. **Physicochemical Drivers of Microcystin Production in Several East African Lakes.**

Globally, eutrophication of freshwater lakes has led to an increase in the occurrence of harmful algal blooms, including blooms of toxic cyanobacteria, posing a risk to those who rely on these waters for drinking, sanitation, recreation or as a source of fish. Comprehensive sets of water and fish samples were collected on a monthly basis between September 2008 and February 2009 from several lakes in Uganda (East Africa). The study sites included two embayments in northern Lake Victoria (Murchison Bay and Napoleon Gulf), Lake Edward, Lake George, Lake Mburo, and the crater lakes Saka and Nkuruba. Microcystin concentrations in water were determined in addition to chlorophyll and nutrient concentrations, phytoplankton community composition, mixing dynamics and light conditions. At nearly all study sites, microcystin concentrations in water regularly exceeded the WHO guideline for microcystin in drinking water of 1.0 μg/L, with the highest concentrations observed in the shallowest, most productive study lakes. *Microcystis* spp. emerged as the cyanobacterial taxon that was primarily responsible for microcystin production in these lakes, and as such, microcystin concentrations were closely linked to environmental factors that favour the development of high *Microcystis* biomass. *Keywords: Africa, Cyanotoxin, Microcystis, Harmful algal blooms.*

POTTER, B.L.[1], LENTERS, J.D.[1], HINKEL, K.M.[2], HEALEY, N.C.[1], IRMAK, A.[1], JONES, S.L.[1], SHULSKI, M.D.[1], and SHENG, Y.[3], [1]School of Natural Resources, University of Nebraska-Lincoln, Lincoln, NE, 68583; [2]Department of Geography, University of Cincinnati, Cincinnati, OH, 45221; [3]Department of Geography, University of California-Los Angeles, Los Angeles, CA, 90095. **Seasonal and interannual variability in the summertime energy balance of a thermokarst lake on the Arctic Coastal Plain of northern Alaska.**

Shallow, thermokarst lakes - which develop atop permafrost - are a prominent landscape feature on the Arctic Coastal Plain (ACP) of northern Alaska. The ACP is vulnerable to ongoing climate change and landscape modification, as thousands of thaw lakes and ponds are impacted by changes in temperature, precipitation, thawing permafrost, and human activity. Although summer in the Arctic is short, incoming solar radiation and lake evaporation are highest at this time of year, and both factors play a significant role in the landscape water balance. Furthermore, lake evaporation is anticipated to increase as the ice-free seasons get longer and water temperatures become warmer. To improve our understanding of these processes, we present a multi-year energy balance study of a thermokarst lake near Barrow, Alaska. Weekly timeseries of net radiation, Bowen ratio, and lake heat storage rate are used to calculate sensible and latent heat fluxes during the 2008-2010 ice-free seasons. The mass-transfer technique is also used to estimate evaporation rates on hourly to daily timescales. Results show that daily evaporation rates range from zero to greater than 4 mm/day, while seasonal patterns can vary significantly from one year to the next. Much of this variability is associated with changes in cloud cover, water temperature, and wind speed. *Keywords: Arctic, Hydrologic budget, Micrometeorology.*

PREFONTAINE, R.C.[1], COLLINS, N.C.[1], and DUNLOP, E.S.[2], [1]University of Toronto at Mississauga, Mississauga, ON; [2]Upper Great Lakes Research Unit, Ontario Ministry of Natural Resources, Peterborough, ON. **Detecting Change in Lake Huron Fish Communities Using Probability of Detection.**

Previous research has shown that a daunting amount of effort is required to statistically detect a halving or doubling of abundance in fish communities when using catch-per-unit effort (CPUE) as an index of abundance. We explore the ability of modified presence-absence statistics; specifically a probability of detection (POD) analysis, to detect change in fish communities. POD analyses take into account the possibility that the organism studied is present at a site but undetected. We expect that POD will be proportional to CPUE at low densities and fairly constant around 1 at higher densities. This plateau in POD would represent a background of constancy against which it would be easier and faster to detect change than the more variable background of CPUE. We compare POD to CPUE using an OMNR electrofishing data set from Lake Huron. Most species exhibit the expected plateau relationship. Power analyses with the data show that POD's sensitivity to change depends on where in the CPUE range the POD plateau begins, i.e., the breakpoint. We survey the variability in the position of the breakpoint and the sensitivity to change among species, habitats, and gear types to evaluate the potential of the POD approach to detect change in Great Lakes fish communities more efficiently than the traditionally used CPUE. *Keywords: Lake Huron, Conservation, Fish.*

QUINLAN, H.R.[1], SCHLOESSER, J.[1], and GREENWOOD, S.[2], [1]U.S. Fish and Wildlife Service, Lake Superior Fish and Wildlife Conservation Office, 2800 Lake Shore Drive, East, Ashland, WI, 54806; [2]Ontario Ministry of Natural Resources, 1235 Queen St. East, Sault Ste. Marie, ON, P6A 2E5. **Lakewide Fish Monitoring Efforts under the Auspices of Coordinated Science and Monitoring Initiative.**

In 2006, the Lake Superior Binational Program coordinators promoted the concept of a 5-year cycle for coordinated lakewide monitoring to the Superior Work Group Ecosystem Committees. The Aquatic Community Committee, with experience in such cooperative endeavors through the Great Lakes Fishery Commission identified several priorities for 2011. Two of these efforts involve nearshore fishery assessment and monitoring. Seven U.S. and Canadian agencies cooperatively initiated a pilot project that utilized the EPA Mid-Continent Laboratory early detection and monitoring protocol to sample for the presence of newly introduced non-indigenous aquatic species at the three busiest shipping ports on Lake Superior; Thunder Bay, Ont. Sault Ste. Marie, MI/Ont. and the St. Louis River estuary, MN/WI. Agencies involved with lake sturgeon rehabilitation cooperatively developed a standardized approach to conduct lakewide juvenile index surveys. Objectives are to describe the lakewide status of juveniles, to establish an index of relative abundance (recruitment, cohort strength, population trends) and to compare biological characteristics among and within locations. We will present findings and progress related to these coordinated science and monitoring efforts.
Keywords: Lake Superior, Monitoring, Fish.

QUINLAN, H.R.[1], PRATT, T.C.[2], GARDNER, W.[2], FRIDAY, M.J.[3], and ECCELSTONE, A.[4], [1]U.S. Fish and Wildlife Service, Ashland Fish and Wildlife Conservation Office, 2800 Lake Shore Drive, East, Ashland, WI, 54806; [2]Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences, 1219 Queen St. E., Sault Ste. Marie, ON, P6A 2E5; [3]Ontario Ministry of Natural Resources, 435 James Street South, Suite 221E, Thunder Bay, ON, P7E 6S8; [4]Trent University, School of Graduate Studies, 1600 West Bank Drive, Peterborough, ON, K9J 7B8. **Parasitism by Sea Lamprey on Lake Sturgeon: Are Sea Lamprey Preventing Lake Sturgeon Rehabilitation in Lake Superior?**

Rehabilitation of lake sturgeon is an important component of a stable, diverse fish Lake Superior community. Despite coordinated efforts to rehabilitate lake sturgeon in the lake since the early 1990s, Great Lakes lake sturgeons were recently listed as threatened by the Province of Ontario and are being considered for listing by the Department of Fisheries and Oceans. Sea lamprey, a non-native parasitic fish now prevalent in the Great Lakes have potential to inhibit lake sturgeon recovery through parasitism of juvenile, sub-adult and adult lake sturgeon. We examined the prevalence and severity of sea lamprey attacks on Lake Superior lake sturgeon captured in assessment activities across a broad spatial scale and compared them to laboratory findings. We found that parasitism by sea lamprey on lake sturgeon varies by life stage and geographic location, and is less prevalent than parasitism on lake trout and other preferred species. Our findings are specific to Lake Superior and lake specific attack rates may vary across the basin.
Keywords: Lake Superior, Fish parasites, Assessments.

QUINN, F.H., 701 Red Mill Dr, Tecumseh, MI, 49286. **Development of Great Lakes Water Supplies, 1860-1899.**

Great Lakes water management requires a thorough understanding of the water balance of the Great Lakes, with emphasis on the net basin water supplies (NBS). The NBS consists of the sum of the precipitation and runoff into a lake minus the evaporation from the lake surface. Historically, Great Lakes water resource studies encompass the 1900-2006 time period and are based on readily available data. This study uses St. Clair Flats water level gauge data to represent Lake St. Clair, which have not been used in international studies for at least 75 years, as well as methodologies to extend the connecting channel flows and changes in lake storage. NBS sequences for the upper Great Lakes are generated which can be used to extend the historical NBS time series by forty years from 1860-1899, an increase of close to 40 percent. The resulting time series includes high episodes for Lakes Superior and Michigan-Huron that are larger than those in the 1900-2006 time series and a low episode for Lake Erie that is lower than the previous record low sequence in the 1930s *Keywords: Hydrologic budget, Water level fluctuations, Climatology.*

RANDALL, R.G. and BROUSSEAU, C.M., Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7P 3V3. **Applying Taylor's Power Law to Fish Catch Data from Nearshore Areas of the Great Lakes: Inferences about Sample Precision and Species Dispersion.**

Taylor's Power Law describes the relationship between the spatial variance of populations and their mean abundance. The power law states that the variance (σ^2) of a population is proportional to a fractional power of the arithmetic mean (μ) such that $\log(\sigma^2) = \log a + b \log \mu$. Parameter b is a measure of the degree of contagiousness, and can be used for interspecific comparisons. We applied Taylor's Power Law to fish catches from near shore areas of the Great Lakes. Boat electrofishing data were used to anchor the study, but we also compared catches from other gears (trap nets and other) and sampling strategies (transect versus point sampling). Consistent with expectations, we found that parameter b was species, gear and area-dependent. Results were used 1) to determine sample size requirements for specified levels of precision; 2) to determine appropriate transformations to achieve normal distribution; and 3) to compare spatial distributions of catches of native and non-native fish species. *Keywords: Spatial distribution, Sample precision, Fish, Invasive species.*

READ, J.[1], MARTINEZ, F.[2], KREIS, R.G.[3], BUNNELL, D.B.[4], SCHWAB, D.J.[2], and MASON, D.M.[2], [1]Great Lakes Observing System, 229 Nickels Arcade, Ann Arbor, MI, 48104; [2]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Road, Ann Arbor, MI, 48108-9719; [3]USEPA Large Lakes Research Station/ORD, 9311 Groh Road, Grosse Ile, MI, 46441; [4]USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105. **Developing a Modeling Framework for Ecosystem Forecasting: the Lake Michigan pilot.**

Recent multi-party efforts to coordinate modeling activities that support ecosystem management decision-making in the Great Lakes have resulted in the recommendation to convene an interagency working group that will develop a pilot approach for Lake Michigan. The process will bring together management priorities identified by existing processes and institutions, such as the LaMP and the Lake Michigan Committee of the Great Lakes Fishery Commission, with the community of Great Lakes modelers to develop a modeling framework within which the outstanding management issues for the lake can be addressed. This presentation will provide an overview of the identified need and recommendations for working group activity including objectives, scope of activities, organizational structure, identified challenges and opportunities and next steps. *Keywords: Model studies, Observing systems, Management.*

READ, J.S.[1], HAMILTON, D.P.[2], MURAOKA, K.[2], WU, C.H.[1], ECKERT, W.[3], LENTERS, J.D.[4], and WINSLOW, L.[5], [1]University of Wisconsin - Madison, 1415 Engineering Dr, Madison, WI, 53706, Centre for Biodiversity and Ecology Research, University of Waikato; [2]Private Bag 3105, Hamilton, 3240, New Zealand; [3]Israel

Oceanographic and Limnological Research, Migdal, 14950, Israel; [4]School of Natural Resources, University of Nebraska-Lincoln, Lincoln, NE, 68583; [5]University of Wisconsin - Madison, 680 N Park St, Madison, WI, 53706. **Drivers of Lake Water Temperature Across Gradients of Climate and Size: A Global Analysis of High-Frequency Instrumented Buoy Data from 25 Temperate Lakes.**

We present high-resolution instrumented buoy data from 25 lakes in temperate latitudes with a wide range of depths (1 to 254 m) and surface areas (0.46 ha to 2,250 km2), where each unique water body contributes to an improved description of the tremendous variability in lakes across regional as well as continental scales. We utilized the data-rich Global Lake Ecological Observatory Network (GLEON; gleon.org) of instrumented buoys to explain both the unique and synchronous characteristics among the 25 lakes, contributing to the description of the variability in lakes across regional and continental scales. Wind speed measured on floating platforms was highly variable across the study lakes, with yearly median winds ranging from 0.42 (Trout Bog, USA) to 10.55 m s-1 (Alexandrina, AUS). We quantified water column stability using Lake Number and found all lakes to exhibit seasonality in stability, while mixing frequency and intensity varied among lakes. We found heat storage in lakes to be related to lake depth, clarity, stability, and geography, which can all affect the regional thermodynamic influence of each lake-type. *Keywords: Comparison studies, Stability, Hydrodynamics.*

REAVIE, E.D.[1], CANGELOSI, A.A.[2], and ALLINGER, L.E.[1], [1]Natural Resources Research Institute, University of Minnesota Duluth, Ely, MN, 55731; [2]Northeast-Midwest Institute, 50 F Street, NW #950, Washington D.C., DC, 20001. **Protists in Ballast Water: Assessment Methods and Performance of a Candidate Ship-board Treatment System.**

Ballast water discharge from ships is a significant source for the introduction of aquatic invasive species. Using a land-based facility in Duluth/Superior Harbor, the Great Ships Initiative (GSI) is evaluating candidate shipboard treatment systems for their ability to prevent the introduction of nuisance species. Numbers of surviving organisms in treated discharge are evaluated using an array of methods. Methods for sampling and assessing live protists (algae and protozoans) in the 10-50 μm size class (as standardized by the IMO) will be detailed. These methods involve use of ambient assemblages, treatment of water via candidate ship-board treatment systems, incubation in control and treatment simulation ballast water tanks, and assessment of propagule viability on discharge. Protist assessments include a vital stain that highlights living cells. The evaluation of a candidate treatment system is presented relative to its ability to neutralize protists. Characterization of treatment performance has been evaluated against the IMO criterion of fewer than 10 viable cells per mL of discharge water. Consequences of more stringent discharge criteria will be discussed. GSI test findings support development of ship-board treatment systems that meet and surpass standards for preventing ballast-mediated aquatic species introductions. *Keywords: Ships, Invasive species, Phytoplankton, Ballast, Algae.*

REDDER, T.M., DEPINTO, J.V., MCCULLOCH, R.D., and GRUSH, J., LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108. **Calibration and Application of a Fine-Scale Model to Evaluate Sediment Dynamics in Toledo Harbor and the Western Basin of Lake Erie.**

Sediment management is a significant challenge in many Great Lakes harbors, where frequent dredging maintenance of navigational systems is often required. Toledo Harbor, which provides navigational access from the western basin of Lake Erie through the lower 10 miles of the Maumee River, provides a good example of these challenges. The navigation channel in Toledo Harbor is subject to significant rates of sedimentation resulting from the combined effects of suspended sediment loading from the Maumee River and wind-wave resuspension and redistribution of bed sediments in Maumee Bay and Lake Erie. Dredging and disposal activities are conducted on an annual basis by the U.S. Corps of Engineers to maintain the channel at considerable expense. A fine-scale, linked hydrodynamic/wind wave/sediment transport model of Maumee River, Maumee Bay, and the Lake Erie western basin was developed using the EFDC and "Simulating Waves Nearshore" (SWAN) models. The linked model framework was calibrated to observed deposition rates in the navigation channel and suspended solids data available for Maumee Bay. The calibrated model was applied to evaluate a suite of sediment management scenarios, including the feasibility of alternative sediment disposal locations and the potential benefits of reducing sediment loadings from the Maumee River.
Keywords: Lake Erie, Sediment transport, Tributaries.

REDISKE, R.R.[1], XIE, L.Q.[1], O'KEEFE, J.P.[1], DYBLE-BRESSIE, J.A.[2], and HAGAR, J.M.[3], [1]Annis Water Resources Institute, 740 W. Shoreline Drive, Muskegon, MI, 49401; [2]NOAA Northwest Fisheries Science Center, 2725 Montlake Blvd. East, Seattle, WA, 98112; [3]Department of Pharmacology, Physiology & Neuroscience, University of South Carolina School of Medicine, Colombia, SC, 29208. **The influence of environmental conditions and hydrologic connectivity on cyanobacteria assemblages.**

We evaluated the temporal and spatial variability of cyanotoxins, water chemistry, and cyanobacteria communities in two lakes of different trophic status. Bear Lake is a hypereutrophic system that flows into mesotrophic Muskegon Lake. The lakes were dominated by the cyanobacteria Microcystis spp., which accounted for 75% of phytoplankton biovolume in Bear Lake and 90% in Muskegon Lake. Total microcystin concentration was positively correlated with cyanobacteria biovolume and turbidity and negatively correlated with ammonia and nitrate. *Cylindrospermopsis raciborskii*, was found in both systems; however, cylindrospermopsin was not detected. The *C. raciborskii* assemblage present in these lakes does not appear to be capable of producing cylindrospermopsin due to the absence of the PKS gene. Although the Bear Lake discharge appears to be the source of *C. raciborskii*, the physical/chemical properties of Muskegon Lake (lower turbidity and temperature, higher nitrate) may constrain the growth of this invasive species. Thus, local conditions in each lake are important in

determining which species are capable of maintaining a viable population. *Keywords: Cyanophyta, Harmful algal blooms, Nutrients.*

REED, A.J., BERGIN, J.M., OSTER, R.J., and HICKS, R.E., Dept. of Biology, University of Minnesota Duluth, SSB 207, 1035 Kirby Drive, Duluth, MN, 55812. **The Diversity of Bacterial Communities Associated with Corroding Steel Structures and Water in the Duluth-Superior Harbor.**

Steel structures in the Duluth-Superior Harbor on Lake Superior are reportedly corroding at an accelerated rate. It is believed that microbial biofilms and tubercles growing on the steel surfaces create anaerobic zones at the metal surface, which is conducive to accelerated corrosion. The bacterial community of tubercles on a rapidly corroding steel structure as well as the adjacent water was sampled and investigated. Whole community bacterial 16S rRNA genes were amplified by PCR, cloned and sequenced. The resultant clone libraries were dominated by members of the *Actinobacteria*, the *Bacteroidetes* and the *Alpha*- and *Betaproteobacteria*. Members of the *Deltaproteobacteria*, the *Cyanobacteria*, the *Acidobacteria* and the *Deferribacteres* were detected in the tubercle scraping clone library only. Microorganisms of the *Deltaproteobacteria* are often anaerobic sulfate-reducing bacteria (SRB) and the byproducts of their metabolism have been shown to accelerate corrosion. Using qPCR, the abundance of the *dsr*A gene indicated a stronger presence of SRBs on steel surfaces at Hallett Dock 5 compared with less corroded sites. Our data suggest that corroding steel structures in this harbor have bacteria that were not detected in the adjacent water column. *Keywords: Anaerobic conditions, Corrosion, Microbiological studies, Bacteria, Species diversity.*

REEVES, H.W., HOLTSCHLAG, D.J., and AICHELE, S.S., USGS Michigan Water Science Center, 6520 Mercantile Way, Suite 5, Lansing, MI, 48911. **Is there one right answer? Why a single estimate may not be the best.**

Components of the Great Lakes water budget may be measured or modeled by a variety of different techniques and methods, and these methods yield different estimates of each quantity. In reconciling these different estimates, we often try to identify a best estimate for a given quantity; but is information lost through this process? We discuss the advantages and disadvantages of retaining different estimates of components of the water budget to focus attention on uncertainty estimation. Appropriate estimation of uncertainty and communication of this uncertainty may improve understanding of the components of the Great Lakes water budget. In addition, this type of analysis may help focus future data collection and systematic analysis to reduce uncertainty in the Great Lakes water budget. *Keywords: Hydrologic budget, Hydrologic cycle, Hydrodynamic model.*

REIMER, J.R.[1], ZHANG, Y.J.[2], GUNAWAN, A.A.[1], and WU, C.H.[1], [1]University of Wisconsin Madison, 1415 Engineering Drive, Madison, WI, 53706; [2]Oregon Health & Science University, 20000 NW Walker Road, Beaverton, OR, 97006. **Meteo-tsunami in Lake Michigan.**

Meteo-tsunami or meteorological induced tsunamis are meteorological in origin but exhibit long-period tsunami characteristics. There are a number of mechanisms that generate meteo-tsunamis such as meteorological disturbances including frontal squalls, atmospheric (pressure) changes, and wind and current interaction. These processes can further generate lake (Proudman) resonance as well as harbor resonance. Thus, enclosed inlets and harbors are sensitive to resonance due to their coastal geometry and bathymetry and can induce large amplitude seiches. An unexpected and destructive meteo-tsunami event that occurred on June 26, 1954 in Lake Michigan impacted the Chicago waterfront resulting in 3 meter high wave heights and eight fatalities. This Lake Michigan meteo-tsunami resulted from atmospheric disturbances at lake resonance that provoked lake seiches and as a consequence resulted in large amplitude waves at the shallow Chicago coast. The 1954 occurrence on Lake Michigan is one specific event caused by frontal movements. Model scenarios are examined to find the eigen-modes of the Lake and to address meteo-tsunami impacts from varying meteorological frontal movements and size. In this talk we will present a numerical modeling tool to assess the coastal hazard and risk areas associated with meteo-tsunamis.

REUSSER, D.A.[1], LEE II, H.[2], FRAZIER, M.R.[2], RUIZ, G.M.[3], FOFONOFF, P.[3], MINTON, M.S.[3], and MILLER, W.[3], [1]2111 SE Marine Science Drive, Newport, OR, 97365; [2]2111 SE Marine Science Drive, Newport, OR, 97365; [3]647 Contees Wharf Road, P. O. Box 28, Edgewater, MD, 21037. **Density Matters: A linear model to evaluate future invasion risk from ballast water discharge.**

To mitigate the introduction of invaders from ballast water many agencies are proposing standards that establish upper concentrations of organisms found in ballast discharge. Ideally, ballast discharge standards will be biologically defensible and adequately protective of the marine environment. We propose a new technique that allows managers to quantitatively evaluate the risk of different concentration based ballast water discharge standards calculated using the per capita invasion probability (PCIP) metric. PCIP represents the likelihood that a discharged organism will become established as a new species in a waterbody or coast. This value is calculated by dividing the total number of ballast water invaders per year by the total propagule pressure. Analysis was done at two scales. Depending upon the assumptions used, this approach predicts that approximately one new species will invade every 10 to 100 years with the current discharges rates for the Pacific Coast of the United States and the International Maritime Organization (IMO) discharge standard for organisms >50 microns. This approach resolves many limitations associated with other methods and it allows policy makers to use risk-based methodologies to establish biologically defensible discharge standards. *Keywords: Invasive species, Ballast.*

RICHARDS, R.P., Heidelberg University, 310 E. Market Street, Tiffin, OH, 44883.
Recent Trends in N and P in the Maumee and Sandusky Rivers, Lake Erie Tributaries.

Particulate phosphorus in these rivers continues to show the downward trend in concentrations and loads that has characterized most of the last 30 years. Highly bioavailable dissolved reactive phosphorus (DRP) showed strong increases 1995 - 2007. However, in the last several years, DRP concentrations and loads have declined. Part of the increase and much of the decrease are due to changes in precipitation, leading to changes in discharge and in recruitment of P from the landscape. Nitrate (NO3) in these rivers accounts for 70-85% of annual loads of total N. Nitrate gradually increased during the 1970's and 1980's, but nitrate loads have decreased since about 2005. Nitrate concentrations began decreasing in the Maumee as early as 1990. Total Kjeldahl Nitrogen (mostly organic nitrogen) has shown gradual downward trends over the last 30 years. Increasing P and decreasing N have led to substantial changes in N:P ratios. NO3:DRP ratio has decreased from ~200 to ~70; TN:TP ratio has decreased from ~25 to ~17. While the dissolved N:P ratios do not appear to be low enough to favor cyanobacterial blooms, the total N:P ratios are now within the range (<20) often considered to favor such blooms. Thus, the recent blooms in the Western Basin may be related not only to increased dissolved phosphorus, but also to decreased N:P ratios.
Keywords: Nutrients, Trends, Lake Erie, Cyanophyta.

RICKETTS, R.D.[1], DU, M.[1], WERNE, J.P.[2], and BROWN, E.T.[1], [1]Large Lakes Observatory and the Department of Geological Sciences, University of Minnesota Duluth, Duluth, MN, 55812; [2]Large Lakes Observatory and the Department of Chemistry and Biochemistry, University of Minnesota Duluth, Duluth, MN, 55812. **Late Quaternary Asian Climate: Peiku Co and Geophysical, Biogeochemical and Sedimentological Proxies.**

Peiku Co is located in a fault-bounded basin on the northern side of the Himalayas. The lake, which has been explored little prior to our Spring 2007 field expedition, is an excellent site for reconstructing past hydrological and monsoon variability as paleo-shorelines attest to effective-moisture-driven changes in lake level and 70% of precipitation in the region is from the southwest Asian monsoon. We recovered over 40km of Chirp sub-bottom seismic profiles and three cores from Peiku Co. The longest core from the basin provides a record extending back to ~15,000 cal years B.P., based on ^{14}C AMS dating. Multi-proxy analyses, including high-resolution magnetic susceptibility, elemental composition (ITRAX X-ray Fluorescence Core Scanner), and carbonate content (carbon couloumetry) have been carried out to compare to other paleoenvironmental records from the Tibetan Plateau. Furthermore, microbial lipids have been measured to test the applicability of GDGT-based temperature reconstructions (TEX_{86} and MBT/CBT) and compound-specific isotope analyses give information on the vegetation history and hydrological conditions in the area. In total, the record from Peiku Co captures the climate transition to warmer and wetter conditions out of the last glacial period. *Keywords: Paleolimnology, Biogeochemistry, Sediments.*

RIDAL, J.J.[1], GULKA, A.[1], MARTY, J.[1], HICKEY, M.B.C.[1], POULAIN, A.[2], and HODSON, P.V.[3], [1]St. Lawrence River Institute of Environmental Sciences, 2 Belmont St., Cornwall, ON, K6H 4Z1; [2]Department of Biology, University of Ottawa, 30 Marie Curie, Ottawa, ON, K1N 6N5; [3]Department of Biology and School of Environmental Studies,, Queen's University, Kingston, ON, K7L 3N6. **Mercury bioaccumulation at nearshore areas in the St. Lawrence River (Cornwall) AOC.**

Mercury contamination of fish and sediments has been a critical issue in the St. Lawrence River (Cornwall) AOC. Research has been focused primarily on offshore depositional areas along the Cornwall waterfront where contaminated sediments and fish have been identified. Few data have been collected in nearshore, vegetative areas which serve as habitat for small fish. We examined mercury concentrations in sediment, amphipods and small yellow perch (Perca flavescens) from nearshore and offshore sites in summer 2010. Total mercury concentrations in top 5 cm sediments ranged 421-5702 ng/g dw in nearshore samples compared with 1936-19386 ng/g dw in offshore samples, although mean values were not significantly different. In contrast, total mercury concentrations in amphipods from nearshore and offshore areas were significantly different (p=0.003), ranging 125-318 ng/g dw and 99-193 ng/g dw, respectively. Mercury concentrations in yellow perch (96-155 mm TL) from nearshore and offshore areas were similar with respective median values of 519 and 502 ng/g dw, which is not surprising given the ability of fish to move between sites. This information together with methylmercury and stable isotope data will be used to assess the relative importance of these nearshore sites as sources of mercury to the river food chain. *Keywords: St. Lawrence River, Bioaccumulation, Mercury.*

RIEDEL, M.S.[1], CREECH, C.T.[2], and NAPERALA, T.R.[3], [1]2981 Yarmouth Greenway Drive, Madison, WI, 53711; [2]Attn: Calvin Creech, US Army Corps of Engineers, Detroit, 477 Michigan Avenue, Detroit, MI, 48226-2523; [3]urs, 10850 Traverse Highway Suite 3365, Traverse City, MI, 49684. **Dam Removal for Restoration of Potamodromous Habitat Restoration in Michigan.**

The Marion Mill Pond dam was constructed on the Middle Branch River in 1878 to drive saw mills for Michigan's timber industry. Originally, this river supported a diverse trout population and upstream of the mill pond, a thriving Brook Trout population still exists. A tributary to the Muskegon River, the Middle Branch River also provided spawning habitat for potamodromous fishes in Lake Michigan. However, thermal and hydraulic impacts from the mill pond and dam have isolated fish populations in the upper section of the river and resulted in the near elimination of downstream cold-water trout habitat. Removal of the dam and draining of Marion Mill Pond would eliminate this barrier to fish passage and allow for reconnection and restoration of the fisheries ecosystem along this 33 mile river. We are conducting conceptual and feasibility analyses and design to develop dam removal and river restoration alternatives. Objectives of these designs will include allowing the river, to the extent practical, to reestablish itself in its original channel, provide for natural flow and flood conveyance, return to natural thermal regime, and restore fish passage through this section of river, ultimately allowing unencumbered fish passage all the way to Lake Michigan. Final design concepts and alternatives will be presented. *Keywords: Fisheries, Ecosystems, Trout.*

RIESSEN, H.P.[1], LINLEY, R.D.[2], ALTSHULER, I.[3], and YAN, N.D.[2], [1]SUNY College at Buffalo, Department of Biology, Buffalo, NY, 14222; [2]York University, Department of Biology, Toronto, ON, M3J 1P3; [3]University of Windsor, Department of Biological Sciences, Windsor, ON, N9B 3P4. **Calcium, Kairomones, and Growth of *Daphnia*.**

Body size is a critical feature in an organism's ecological interactions. In freshwater zooplankton communities, fecundity, survivorship, competitive success, and ecosystem impacts are all strongly dependent on body size. While food quality and quantity play a critical role in determining growth and body size in *Daphnia*, the chemical environment to which these animals are exposed may also be of great importance. We investigated the effects of calcium concentration (0.5-5.0 mg/L) and the presence of kairomones released by predatory *Chaoborus* larvae on juvenile growth and body size of *Daphnia pulex*. Lower calcium levels did not affect size at birth in *D. pulex*, but did reduce subsequent growth, resulting in smaller body sizes in the later juvenile instars. A calcium threshold for juvenile growth exists at about 1.5 mg/L, below which body size is significantly reduced. The presence of *Chaoborus* kairomones significantly increased *D. pulex* body size in all four juvenile instars. In instars 2-4, however, this effect only occurred at higher calcium concentrations. The lowest calcium level (0.5 mg/L) prevented a kairomone-induced increase in body length. We conclude that the chemical environment of *Daphnia* has a potentially strong influence on its ecological interactions in lakes. *Keywords: Zooplankton, Life history studies, Crustaceans.*

RILEY, S.C.[1], BLEHERT, D.[2], KENOW, K.[3], FOGARTY, L.R.[4], WHITE, L.[2], SLEEMAN, J.[2], LAFRANCOIS, B.M.[5], BOOTSMA, H.A.[6], and OTTO, C.[7], [1]USGS Great Lakes Science Center, Ann Arbor, MI; [2]USGS National Wildlife Health Center, Madison, WI; [3]USGS Upper Midwest Environmental Sciences Center, LaCrosse, WI; [4]USGS Michigan Water Science Center, Lansing, MI; [5]USGS National Park Service, St. Croix Watershed Research Station, Marine on St. Croix, MN; [6]Great Lakes WATER Institute, University of Wisconsin-Milwaukee, Madison, WI; [7]NPS Sleeping Bear Dunes National Lakeshore, Empire, MI. **Botulism Type E Toxin in Northern Lake Michigan.**

Botulism is caused by neurotoxins produced by the bacterium Clostridium botulinum, which can cause paralysis and death of intoxicated vertebrates. Periodic outbreaks of type E botulism have caused die-offs of fish-eating birds in the Great Lakes since at least the 1960s, but outbreaks have become more common and widespread since 1999. Extensive bird mortality in northern Lake Michigan near Sleeping Bear Dunes National Lakeshore (over 4,150 birds in 2007) has caused great public concern, yet the actual mechanisms of toxin exposure for birds remain unknown. The National Park Service has been conducting many studies in the area since 2007, and in 2010, the U.S. Geological Survey, with support from the Great Lakes Restoration Initiative, began an intensive study to better understand the occurrence, sources, and mechanisms of botulism type E intoxication in northern Lake Michigan. This presentation will summarize activities being coordinated between the USGS, NPS, and university researchers on Botulism in northern Lake Michigan *Keywords: Lake Michigan, Coastal ecosystems, Avian ecology.*

RIPPKE, M.B.[1], FARRELL, J.M.[2], TEECE, M.A.[3], DISTLER, M.T.[2], LEOPOLD, D.J.[2], and MULLINS, H.T.[4], [1]Department of Natural Resources and Environment, Lansing, MI, 48909-7773; [2]SUNY College of Environmental Science and Forestry, Department of Environmental and Forest Biology, Syracuse, NY, 13210; [3]SUNY College of Environmental Science and Forestry, Department of Chemistry, Syracuse, NY, 13210; [4]Syracuse University, Department of Earth Sciences, Syracuse, NY, 13244. **Evidence of a dry Hypsithermal climate and the Nipissing Flood from an Upper St. Lawrence River (New York) coastal wetland.**

Wetland and upland vegetation changes over a period of 8,300 years, and sedimentary 13C, 15N, and C:N changes from the past 10,500 years were examined in a St. Lawrence River coastal wetland. Large amounts of grass (Poaceae) pollen found in Hypsithermal sediments suggest that the climate was dry in northern New York State. Presently, native grassland remnants in northern New York provide evidence for more widespread prairie-like ecosystems during the Hypsithermal. Evidence of the Nipissing highstand was found between 5,200 and 4,500 YBP, indicated by a +8 per mil shift in sediment 13C, increased carbon mass accumulation rates, and a period of depressed C:N ratios. These geochemical changes during the Nipissing were accompanied by a ≈70% decline of grass pollen over 500 years. Climate cycles, 3,300 years in duration, were inferred from >50% increases in Poaceae (grass) pollen relative abundance.
Keywords: Climate change, Palynology, Coastal wetlands, Vegetation change, Water level fluctuations.

ROBERTSON, D.M. and SAAD, D.A., U.S. Geological Survey, 8505 Research Way, Middleton, WI, 53562. **Allocation of Nutrient Inputs to the Great Lakes by Source and River Basin Using SPARROW Watershed Models.**

To address eutrophication problems in the Great Lakes, targets were established for phosphorus (P) loads to each lake, and TMDLs are being developed for many tributaries. Because detailed nutrient and flow data are not available for most tributaries, it is difficult to determine if target loads are being met, what are the main sources of nutrients are to each lake, and where the largest nutrient sources originate. To fill the gaps left by sparse monitoring data, SPARROW (SPAtially Referenced Regression On Watershed attributes) models were developed for P and nitrogen (N) for the Great Lakes watershed and vicinity. SPARROW model results are used to: 1) estimate P and N loads to each Great Lake and from all of their tributaries (from the U.S. contributing area); 2) rank individual tributaries based on total loads and relative yields; 3) determine the relative magnitude of P and N inputs from major sources (atmospheric, point sources, fertilizers, manure, fixation, and forested and urban lands); and 4) compare the results from #2 and # 3 with those for nearby large river watersheds. To forecast potential changes in loads associated with various future climate-change and land-use change scenarios, a regional model (HydroSPARROW) is being developed which links SPARROW with several water-quantity models. *Keywords: Nutrients, Watersheds, Computer models.*

RODENBURG, Z.L. and HORNBUCKLE, K.C., Department of Civil and Environmental Engineering, The University of Iowa, 4105 Seamans Center for the Engineering Arts and Sciences, Iowa City, IA, 52242. **Polychlorinated Biphenyl Congeners in Lake Michigan Air and Water in 2010.**

Polychlorinated biphenyl (PCB) concentrations in air and Lake Michigan water near Chicago declined rapidly following the production ban of Aroclors over 30 years ago. However, since the early 1990s, concentrations of these chemicals have remained relatively constant. During summer of 2010, a field sampling expedition was conducted on Lake Michigan aboard the EPA R/V Lake Guardian approximately 5 km off the coast of Chicago. High-volume air and water samples were collected using Amberlite XAD-2 resin as an adsorption media and quartz fiber filters to collect particles in both phases. The XAD and filter samples were extracted via accelerated solvent extraction and analyzed for 209 PCB congeners using tandem mass spectrometry. Field and laboratory blanks were prepared and analyzed using the same approach. Quality assurance and control strategies utilized blanks, sample replicates, surrogate standards, internal standard methods and analysis of standard reference materials. Concentration data elicited from each sample was used to calculate instantaneous PCB congener fluxes across the air-water interface at this location. The results were then used in conjunction with an ongoing regional transport model to predict the effect of specific emissions from the city of Chicago on the magnitude of PCB deposition to Lake Michigan. *Keywords: PCBs, Instantaneous flux, Lake Michigan, Chicago, Air-water interfaces, Emissions.*

ROEHM, C.L.[1], ANDERSON, E.J.[2], BELETSKY, D.[2], PERRELLI, M.[1], SINGER, J.[1], and VERMETTE, S.[1], [1]Buffalo State College, 1300 Elmwood Avenue, Buffalo, NY, 14222, US; [2]University of Michigan, CILER, 4840 South State St.,, Ann Arbor, MI, 48108-9719, US. **Hydrodynamics of Nearshore Lake Erie: An Insight into Winter Conditions.**

Little is still known about the hydrodynamics of Lake Erie during the winter season. Changes in the ice cover thickness and extent, along with ice and water temperature, movement and mixing can have large implications for biological and chemical processes, and hence, the water quality and health of a lake. In addition, these changes can impart complex feedback mechanisms with the atmosphere. As part of a

nearshore study on the long-term impacts of climate and environmental change on Lake Erie, an acoustic wave and current meter (AWAC; Nortek) and thermistor node were deployed in the Buffalo region during the winter 2010-2011. The AWAC has three acoustic transducers and the reflected sound is used to determine the current speed and direction in a series of depth layers throughout the water column. In addition, due to an acoustic surface track (AST), the directional wave spectrum is accounted for and the combination of currents, waves, and ice keel depth measurements permits analysis of ice dynamics during the winter months. The data obtained from this project are being used to refine and validate the FVCOM hydrodynamic model. It is important to monitor such parameters over the long term in order to account for lags between drivers and responses of the ecological systems. *Keywords: Ice, Currents, Lake Erie, Atmosphere-lake interaction.*

ROEHM, C.L.[1], ANDERSON, E.J.[2], BELETSKY, D.[2], PERRELLI, M.[1], SINGER, J.[1], and VERMETTE, S.[1], [1]Buffalo State College, 1300 Elmwood Ave., Buffalo, NY, 14222, US; [2]University of Michigan, CILER, 4840 South State St.,, Ann Arbor, MI, 48108-9719, US. **Observing and Monitoring systems in Nearshore Lake Erie.**

The purpose of this project is to expand the existing network of observation buoys in the Great Lakes through the deployment of three buoys in the nearshore areas of the Central and Eastern basins of Lake Erie. The nearshore areas are directly adjacent to major tributaries and/or Areas of Concern (AoCs), notably Ashtabula and Buffalo River, as well as Cattaraugus Creek. Deployment of an automated underwater vehicle (AUV) will augment the buoys by providing directed observations and increased spatial resolution. Long term monitoring at these sites will provide an up-to-date status of changes in indicators of the health of Lake Erie. A submerged monitoring system will be maintained through the winter. The system is designed to provide near real time measurements of chemical, physical and biological parameters in the water column and in the atmosphere. The products will be made readily available to scientists, decision makers, educators and the public at large, in order to improve the global understanding of the ecosystems and the issues facing them. The data is, in addition, being used for the calibration and validation of hydrodynamic models and for future assimilation into regional ecosystem models. The impacts of environmental and climate change are being addressed through this long-term monitoring initiative. *Keywords: Buoys, Lake Erie, Monitoring.*

ROGERS, M.W., BUNNELL, D.B., MADENJIAN, C.P., and WARNER, D.M., USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105. **Modeling Lake Michigan's Offshore Food Web.**

Lake Michigan's offshore food web has changed in recent decades due to species invasions, decreased productivity, decreased total prey fish abundance, and varied stocking rates of top piscivores. We developed an ecosystem-based model to quantitatively represent these changes and explore their effects on trophic energy flows and food web connectivity. We built our model using Ecopath with Ecosim and initiated the model using 1987 data, which was prior to significant recent invasions such as zebra and quagga mussels. We fit the model to assessment and survey data available through 2009. We used the model to evaluate changes in energy flows prior to significant species invasions and after they were established. The model also provided a tool to test proposed hypotheses of invasive species effects on ecosystem food web dynamics and ecosystem productivity. *Keywords: Lake Michigan, Ecosystem modeling, Food chains.*

ROSEMAN, E.F.[1], BENNION, D.H.[1], BOASE, J.C.[2], BOUCKAERT, E.[3], CALDWELL, C.[2], CRAIG, J.M.[1], HONDORP, D.W.[1], HUTTON, M.[2], KENNEDY, G.A.[1], LINCOLN, K.[1], MANNY, B.A.[1], SOPER, K.[4], and WADE, S.[1], [1]USGS Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105; [2]USFWS Alpena Fish and Wildlife Conservation Office; Waterford Sub-Station, 7806 Gale Road, Waterford, MI, 48327; [3]Dept. Biology, MI Technological University, 1400 Townsend Drive, Houghton, MI, 49931; [4]Ontario Ministry of Natural Resources Lake Erie Management Unit, 320 Milo Rd, RR 2, Wheatley, ON, N0P 2P0. **Using Ichthyoplankton Surveys to Assess Fish Spawning and Nursery Habitats in the Huron-Erie Corridor.**

The Huron-Erie Corridor (HEC) is a viable spawning and nursery area for Great Lakes fishes and also serves as a corridor for ichthyoplankton movements from upper Great Lakes to Lake Erie. Complementing recent fish population and habitat restoration efforts in the river, we assessed the dynamics of the ichthyoplankton community to document spawning success of river residents as well as movement of fishes from upstream sources. Sampling was conducted during spring and summer in 2006 through 2010 at varying intensities and spatial extent in the Detroit River and in 2010 in the St. Clair River to assess species composition, timing of occurrence, density, and transport of larvae in the HEC. Weekly active sampling was conducted using bongo nets in main channel and nearshore areas. We will present data showing the timing and magnitude of abundance for select species and also compare contemporary results with data from a similar survey conducted during the late 1970s. Our results show a vastly different larval fish community than that observed during the 1970s survey likely due to increased spawning of native fishes in the HEC as well as changes to the Lake Huron fish community. *Keywords: Life history studies, St. Clair River, Detroit River.*

ROSWELL, C.R.[1], POTHOVEN, S.A.[2], and HOOK, T.O.[1], [1]Purdue University, Department of Forestry and Natural Resources, 195 Marstellar St., West Lafayette, IN, 47907; [2]NOAA-GLERL Lake Michigan Field Station, 1431 Beach St., Muskegon, MI, 49441. **Do Sub-Optimal Foraging Strategies Reduce Recruitment of Yellow Perch in Saginaw Bay?**

Recent high production of young yellow perch, a species important to the ecology and fisheries of Saginaw Bay, has not resulted in high recruitment to the older perch population. The collapse of Lake Huron alewives in 2003 likely improved survival of larval perch, which may have led to density dependent processes that affect juveniles.

However, the absence of alewives also likely restructured zooplankton communities, and invasive species such as *Bythotrephes*, dreissenid mussels, and round gobies also potentially influence prey availability. We tracked patterns of growth, consumption, and diet composition through the first year of life, and evaluated diet preferences of age-0 perch using an index of selectivity. We also compared diet composition to environmental variables such as round goby and predator abundances, which could influence foraging trade-offs for young perch. During the entire first growing season, yellow perch diets were dominated by cladocerans and copepods, while larger benthic prey items comprised a much smaller component of diets. Growth of age-0 perch slowed during late summer and fall, despite near-optimum temperatures. Our data indicate slow growth in Saginaw Bay likely increases starvation and predation risk for young perch, potentially limiting recruitment. *Keywords: Yellow perch, Saginaw Bay, Diets, Zooplankton.*

ROUTE, W.T.[1], DYKSTRA, C.R.[2], RASMUSSEN, P.W.[3], KEY, R.[1], and MEYER, M.W.[3], [1]National Park Service, Great Lakes Inventory and Monitoring Network, Ashland, WI, 54806; [2]Raptor Environmental, 7280 Susan Springs Drive, West Chester, OH, 45069; [3]Wisconsin Department of Natural Resources, Rhinelander, WI, 54501.
Emerging Contaminants in Nestling Bald Eagles at Three National Parks in the Upper Midwest.

We monitored bald eagle productivity and contaminants in the Apostle Islands National Lakeshore, St. Croix National Scenic Riverway, and Mississippi National River and Recreation Area. 154 plasma and 142 breast-feather samples (years 2006-2009) were analyzed for mercury, lead, DDT (and metabolites), PCBs (75 congeners), PBDEs (9 congeners), and PFCs (16 analytes). We present results on eagle productivity and PBDE and PFC patterns/trends. All areas averaged >1.0 young per nest, above the threshold for a healthy bald eagle population. The Apostle Isl. had the lowest productivity, the Miss. NRRA the highest. Geometric mean concentrations of PBDEs ranged from 1.39 ug/L in the upper St. Croix in 2006 to 16.8 ug/L in the Miss. NRRA in 2007. Spatial patterns of PBDEs were similar to industrial pollutants such as PCBs. PBDEs increased at the Apostle Isl. until 2007 then declined through 2009. PFCs were found in all nestlings, with PFOS predominating (~60% by volume). PFOS was high in lower St Croix (1584 ug/L) and Miss. NRRA(1247 ug/L), low in the upper St. Croix (13.4 ug/L) and moderate in the Apostle Isl. (145-174 ug/L). PFDS made up 26% of the PFC plasma volume in the Miss. NRRA but <1% in Lake Superior sites. PFOA was <1% by volume in all areas but highest in Apostle Isl. birds. Our data suggests that PFCs are declining.
Keywords: Monitoring, PFCs, Avian ecology, Contaminants, PBDEs, Bald eagle.

ROWE, M.D.[1], PAUER, J.J.[1], KREIS, R.G.[1], and DOLAN, D.M.[2], [1]U.S. EPA Large Lakes Research Station, 9311 Groh Rd., Grosse Ile, MI, 54311; [2]University of Wisconsin - Green Bay, Natural and Applied Sciences, Green Bay, WI, 54311. **Modeling the Response of Nutrient Concentrations and Primary Productivity in Lake Michigan to Nutrient Loading Scenarios.**

A water quality model, LM3 Eutro, will be used to estimate the response of nutrient concentrations and primary productivity in Lake Michigan to nutrient loading scenarios. This work is part of a larger effort, the Future Midwestern Landscapes study, that will estimate the production of ecosystem services associated with land use scenarios that include increased biofuel production and enhanced conservation practices. Previous calibration of LM3 Eutro focused on phytoplankton (chlorophyll-a) and phosphorus. The current effort will include calibration of the nitrogen cycle, which is an overarching theme of the ecosystem services research program. The ability of the model to simulate observed phosphorus and nitrogen concentrations as well as phytoplankton production will be evaluated over the period 1994 to 2008. Recent estimates of nitrogen and phosphorus loads for the period 1996 to 2008 will be used along with loads from the 1994 to 1995 Lake Michigan Mass Balance study. The presentation will include discussion of the nitrogen cycle in Lake Michigan and its representation in LM3 Eutro. This abstract does not necessarily represent the official position of U.S. EPA.
Keywords: Lake Michigan, Nutrients, Model studies.

ROZUMALSKI, L.L.[1], KUHN, M.T.[2], and RIEDEL, M.S.[1], [1]2981 Yarmouth Greenway Dr., Madison, WI, 53711; [2]477 Michigan Ave., Detroit, MI, 48226. **Fond du Lac Creek Restoration to Enhance Fish Habitat and Passage in the St. Louis River Watershed Area of Concern.**

Fond du Lac Creek is a designated trout stream and once had a diverse fish assemblage, including naturally reproducing brook trout. Historically, the stream also provided spawning habitat for Lake Sturgeon. The creek is on the Fond du Lac Band of Lake Superior Reservation and served as a popular fishery for Band members in the past, providing an important cultural and subsistence resource. Recent fish assessments have yielded few or no trout, indicating a seriously impacted resource. Roadbed reconstruction in the late 1970's resulted in a steep embankment at the road crossing just upstream of the creek's confluence with the St. Louis River. The culvert installed at the crossing was improperly aligned with the stream. The downstream end of the culvert is perched roughly two feet above the water level during normal flows and is too high to allow fish passage and hydrologic connection to the St. Louis River. Aside from this physical impairment, however, monitored habitat and water quality parameters indicate a healthy coldwater stream ecosystem, supporting diverse macroinvertebrate and fish communities. We will discuss alternatives for modifying the road crossing in order to restore fish passage, reconnect valuable habitat for fisheries within the St. Louis River, and help meet management goals established for the area of concern. *Keywords: St. Louis River AOC, Ecosystem health, Fish management.*

RUBERG, S.[1], MEADOWS, G.[2], MUZZI, R.[1], BROWN, H.[2], LANE, H.[1], PURCELL, H.[2], and CONSTANT, S.[1], [1]NOAA Great Lakes Environmental Research Lab, 4840 S. State Rd, Ann Arbor, MI, 48108; [2]University of Michigan Marine Hydrodynamics Lab, 1085 S. University Ave., Ann Arbor, MI, 48109. **Recent Developments in Real-Time Environmental Sensing.**

NOAA's Great Lakes Environmental Research Lab and The University of Michigan's Marine Hydrodynamics Lab have made significant progress in developing nearly operational buoy and sensor technologies and in extending Great Lakes coastal observing system networks. Successful projects have resulted in robust observing system deployments that provide real-time information addressing basic Great Lakes science as well as ecosystem forecasting. Recent system deployments support navigation safety, rip current warnings, fisheries research, drinking water safety, and harmful algal bloom warnings. Future projects will address wave sensor improvements, year round observations, and the use of autonomous vehicles to increase spatial coverage of physical, chemical, and biological parameters. â€¨ *Keywords: Measuring instruments, Observing systems, Ecosystem forecasting.*

RUCINSKI, D.K.[1], BELETSKY, D.[2], DEPINTO, J.V.[1], SCAVIA, D.[2], and SCHWAB, D.J.[3], [1]LimnoTech, 501 Avis Dr, Ann Arbor, MI, 48108; [2]School of Natural Resources and Environment, University of Michigan, Ann Arbor, MI, 48109; [3]NOAA-Great Lakes Environmental Research Lab, 4840 S. State Rd, Ann Arbor, MI, 48108. **A 3-Dimensional Advanced Aquatic Ecosystem Model for Lake Erie.**

Hypoxia (dissolved oxygen < 2mg·L-1) in the central basin of Lake Erie has reemerged as a potential hazard to ecosystem health, despite reductions in nutrient loading required by the Clean Water Act, the Great Lakes Water Quality Agreement, and other policy changes. A 3-dimensional modeling framework is presented, with the capability to simulate advanced nutrient cycling processes and the lower food web, including multiple classes of zooplankton and phytoplankton, dreissenids, and benthic algae. An application of a calibration of this model is shown, with respect to the processes controlling dissolved oxygen depletion in the lake. *Keywords: Eutrophication, Lake Erie, Model studies.*

RUDSTAM, L.G.[1], HOLECK, K.T.[1], WATKINS, J.M.[1], and STEWART, T.J.[2], [1]Cornell Biological Field Station, Department of Natural Resources, Cornell University, Bridgeport, NY, 13030; [2]Onttario Ministry of Natural Resources, Rural Road # 4, Picton, ON, K0K 2T0. **Lake Ontario food web disruption - comparisons with the upper lakes.**

Food web disruptions are not limited to the upper Great Lakes. Recent changes in Lake Ontario include many of the same patterns as observed in Lake Huron and Michigan, including proliferation of quagga mussels, disappearance of Diporeia, declines in alewife, increases in Bythotrephes, declines in cyclopoid copepods and cladocerans, increases in deep chlorophyll maxima and associated zooplankton like Limnocalanus, and decreases in spring diatom blooms. In the past Lake Ontario has been more productive than the upper lakes, but this pattern is changing. We believe comparisons with the upper lakes to be useful for predicting future ecosystem changes in Lake Ontario, and conversely, that time trends of lower trophic levels in Lake Ontario can be

useful for evaluating the likelihood of several proposed mechanisms causing ecosystem change in the upper lakes. Here we use Lake Ontario time series to evaluate the likelihood of potential causes for declines in epilimnetic zooplankton abundance, including predation by Bythotrephes and competition with quagga mussels, and contrast the Lake Ontario data with similar studies in the upper lakes. *Keywords: Diatoms, Mussels, Zooplankton.*

RUTHERFORD, E.S.[1], VANDERPLOEG, H.A.[1], HOOVER, A.[2], CAVALETTO, J.F.[1], LIEBIG, J.R.[1], POTHOVEN, S.A.[1], MASON, D.M.[1], BOURDEAU, P.E.[3], and PEACOR, S.D.[3], [1]4840 S. State Rd., Ann Arbor, MI, 48108; [2]University of Michigan CILER, 4840 S. State Rd, Ann Arbor, MI, 48108; [3]Michigan State University, 10 D, Natural Resources Bldg, Dept Fisheries and Wildlife, East Lansing, MI, 48824. **Fish Recruitment Dynamics in the Newly Illuminated, Spatially Complex Food Web of Lake Michigan.**

Invertebrate invaders have likely lowered the recruitment potential of key fish species in Lake Michigan. The recent expansion of dreissenid mussels into deep water has re-engineered nutrient and carbon flows, greatly reduced the phytoplankton food base and increased light intensity, potentially altering vertical migrations and densities of zooplankton and fish larvae. Although zooplankton abundance as a whole has decreased, abundance of the visual predator Bythotrephes has increased, creating a potential bottleneck to recruitment through its competition with larval fishes for zooplankton. During April, July and September 2010, we described spatial and temporal distributions of chlorophyll, zooplankton and fish larvae along cross-isobath transects in Lake Michigan using hydroacoustics, plankton survey system, opening/closing vertical net tows, Tucker trawls, and zooplankton pump. Our samples revealed that zooplankton were concentrated along with fish larvae and Bythotrephes in the metalimnion, in contrast to earlier observations for several fish taxa and Bythotrephes before mussels expanded into deep water. We discuss the consequences of the altered light regime, and spatial distributions and densities of zooplankton on fish larvae diets, growth rates, survival and potential recruitment. *Keywords: Invasive species, Fish larvae, Spatial distribution, Lake Michigan.*

RUTHERFORD, S.[1], STURTEVANT, R.A.[2], and WALTERS, H.D.[3], [1]Eastern Michigan University, Ypsilanti, MI; [2]NOAA Great Lakes Sea Grant Network, 4840 South State Road, Ann Arbor, MI, 48108; [3]Ashland University, Ashland, OH. **The Great Lakes Climate Change Science and Education Systemic Network.**

The Great Lakes Climate Change Science and Education Systemic Network (GLCCSESN - http://greatlakesclimate.org/)is an NSF funded Climate Change Education Partnership that takes a regional focus on the unique characteristics of climate change impacts on the Great Lakes region and the intersection of regionally-based climate research with regionally-based climate education in order to enhance opportunities for research-education partnerships and build a consensus framework to guide collaboration.

GLCCSESN is working to integrate the disparate institutions and individuals engaged in climate science research, climate literacy research, and climate education activities within the Great Lakes region. This systemic network is working to 1) advance discovery while promoting teaching, training and learning; 2)broaden the participation of underrepresented groups; 3)enhance the infrastructure for research and education; 4) broadly disseminate Great Lakes climate science through partnership with diverse formal and informal education institutions; and 5) benefit society by partnering to influence climate change education and policy in the Great Lakes region. *Keywords: Climate change, Education, Outreach.*

RUZYCKI, E.M., AXLER, R.P., HENNECK, J., WILL, N.J., and HOST, G.E., Natural Resources Research Institute, University Minnesota - Duluth, Duluth, MN, 55811.
Sediment, phosphorus and mercury loads from four Western Lake Superior watersheds.

Total suspended sediment (TSS) total mercury (THg) and total phosphorus (TP) have been shown to be strongly correlated to turbidity in many watersheds. High frequency *in situ* turbidity can provide estimates of these pollutants over a wide range of hydrologic conditions. Concentrations and loads were estimated in four Western Lake Superior watersheds from 2005-2006 using regression models relating continuous turbidity data to grab sample measures of suspended sediments, mercury, and phosphorus during differing flow regimes. Suspended sediment loads estimated using the turbidity surrogate were compared to those made using FLUX software, a standard assessment technique based on discharge and grab sampling for TSS. Stream specific turbidity vs. TSS measures were strongly correlated ($r2 = 0.6$ to 0.95; $p < 0.05$). Total mercury values ranged from 1 to 28 ng/L throughout the open water season and showed a close relationship with TSS ($r2 = 0.82$, $n = 23$; $p < 0.05$) for all four streams. Mercury loads to Lake Superior were estimated to be 10 to 85 g/yr with watershed yields ranging from 0.6 to 3.8 g/km2/yr. Continuous turbidity monitoring appears to be a reasonable surrogate for both sediment and total mercury concentration, providing information when manual sample collection is difficult. *Keywords: Watersheds, Pollution load, Monitoring.*

RYAN, D.J., HOOK, T.O., and SEPULVEDA, M.S., Purdue University, Department of Forestry and Natural Resources, West Lafayette, IN, 47906. **Non-lethal Effects of Lampricide Exposure on Non-target Species.**

Sea lampreys (*Petromyzon marinus*) have decimated fish populations in the Laurentian Great Lakes since their introduction. To counter sea lamprey predation effects, a variety of control programs exist including targeting sensitive ammocetes through treatment of known lamprey spawning sites with the lampricide 3-trifluoromethly-4-nitrophenol (TFM). However, this method is somewhat indiscriminate and may affect other non-target fishes, especially during early life stages. To investigate this possibility, we exposed non-target species, lake sturgeon (*Acipenser fulvescens*) and rainbow trout (*Oncorhynchus mykiss*), to different concentrations of TFM. These two

species co-occur with sea lamprey in TFM-treated streams and have different known tolerances to TFM. We assess the toxic action of TFM by mapping metabolomic profiles of fishes exposed to TFM, and compare metabolite profiles across species and varying concentrations of TFM. Moreover, we evaluate sub-lethal effects of TFM by examining short term growth effects post exposure. Initial results point to minor effects of TFM exposure on short term growth of non-target species. *Keywords: Biological invasions, Lampricide, Fish toxins, Fish behavior.*

SABORIDO BASCONCILLO, L., BACKUS, S.M., STRUGER, J., and LEE, H.B., Water Science and Technology Directorate, Environment Canada, Burlington, ON, L7R 4A6, Canada. **Occurrence of Bisphenol A in the Canadian Aquatic Environment.**

Bisphenol A (BPA) is widely used in the production of polycarbonate plastics, epoxy resins and flame retardants. BPA is ubiquitous in the aquatic environment, biota and human tissues from all over the world. BPA is also a xenoestrogen and a well-studied endocrine disruptor. Recent research has shown that environmental levels of BPA could be involved in the development of certain cancers, hypertension, diabetes and obesity in humans. Recently, it has been proposed to set a release limit for BPA in industrial effluents in Canada, however, there is no information regarding the BPA levels in the canadian aquatic ecosystem. The main goal of this study was to provide information regarding BPA levels in the Canadian aquatic environment. BPA was measured in freshwater samples collected from 35 locations across Canada and it was detected in 57% of the samples, mainly in those sites associated with urban activities. The maximum concentration measured in water was 3,650 ng/L in Hamilton's harbor downstream of the Hamilton's sewage treatment plant. BPA levels in rivers in Canada were in the range of 5-620 ng/L. Overall, BPA levels were higher in water samples from sites that were influenced by waste water treatment plants and/or urbanization. No seasonal pattern was observed for BPA levels in the sampling locations studied. *Keywords: Environmental contaminants, Urban watersheds, Water quality.*

SASS HILBRICH, D.J.[1], HYDE, R.[2], BERTRAM, P.[1], and STADLER-SALT, N.[2], [1]U.S. EPA and Oak Ridge Institute for Science and Education, 77 West Jackson Boulevard (G-17J), Chicago, IL, 60604, United States; [2]Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6, Canada. **Review of the State of the Great Lakes Ecosystem Conference (SOLEC) Suite of Great Lakes Indicators.**

The State of the Lakes Ecosystem Conference (SOLEC) is a coordinated, consistent and science-based reporting on the state of the Great Lakes ecosystem, which is co-organized by the United States Environmental Protection Agency and Environment Canada and mandated by the Great Lakes Water Quality Agreement. In order to complete the reporting process, SOLEC relies on a series of Great Lakes indicators to assess the overall ecosystem health. In 2010, collaboration between federal, state, provincial and local management organizations assisted in an intensive review of the Great Lakes indicator suite to help ensure that data are being collected, analyzed and reported in a

concise and effective manner. This review consisted of multiple steps including; taking indicator inventory, assessing the strengths and weaknesses of the suite, convening an independent review panel, adopting a new framework (DPSIR) and ensuring that the indicators reflect the new framework for assessing the Great Lakes ecosystem health. The review led to a new, improved, updated and representative suite of Great Lakes indicators that allows for well-informed decision making across the Great Lakes basin.
Keywords: Decision making, Indicators, Ecosystem health.

SAYERS, M.J., BROOKS, C.N., and SHUCHMAN, R.A., 3600 Green Court, Suite 100, Ann Arbor, MI, 48105. **Mapping Cladophora in the Great Lakes Using Multi-scale Satellite Imagery.**

We have developed a new remote sensing algorithm to map Cladophora extent and biomass in the near-shore waters (0-15 meters depth) in the Great lakes. The algorithm utilizes the blue, green and red visible bands of electro-optical satellites such as MODIS, MERIS, Landsat TM and higher spatial resolution (~2m) commercial multispectral data from GeoEye and DigitalGlobe. The algorithm maps Cladophora using a depth invariant bottom reflectance index and has been successfully tested on satellite data sets of varying resolutions of the Sleeping Bear Dunes National Lakeshore (SBDNL) in Lake Michigan where there is extensive "lake" truth on Cladophora extent and biomass. The utility of mapping Cladophora using 1km MODIS or 330 meter MERIS data with its daily acquisitions is compared to the results from the 30 meter Landsat and the commercial 2 meter high resolution data. A time series analysis, both annually and seasonally, of Cladophora extent at SBDNL was also done using historical Landsat data.
Keywords: Cladophora, Remote sensing, Lake Michigan.

SCHAEFFER, J.[1], FIELDER, D.G.[2], GODBY, N.[3], BOWEN, A.[4], O'CONNOR, L.[5], PARRISH, J.[6], GREENWOOD, S.[7], CHONG, S.C.[7], and WRIGHT, G.[8], [1]USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105; [2]Michigan Department of Natural Resources, Alpena Fisheries Research Station, Alpena, MI, 49707; [3]Michigan Department of Natural Resources, Northern Lake Huron Management Unit, Gaylord, MI, 49735; [4]U.S. Fish and Wildlife Service, Alpena Fisheries Resource Office, Alpena, MI, 49707; [5]Fisheries and Oceans Canada, Great Lakes Laboratory ofr Fisheries and Aquatic Sciences, Sault Ste. Mari, ON, ON6PA 6W4; [6]Bay Mills Indian Community, Brimley, MI, 49715; [7]Ontario Ministry of Natural Resources, Sault Ste. Marie, ON, ONP6A; [8]Chippewa/Ottawa Resource Authority, Sault Ste. Marie, MI, 49783. **Long-term trends in the Saint Marys River open water fish community.**

We examined trends in species composition and abundance of the St. Marys River fish community. Data were available approximately once every six years from 1975 through 2006, and size and age data were available after 1995. We also compared survey data in 2006 with creel results that year and historical surveys. We found a coolwater fish community with apparent little variation in species composition, and little variation in abundance since 1975. However, we did find trends among target species sought by

anglers: centrarchids increased, percids appeared stable, and both northern pike (Esox Lucius) and cisco (Coregonus artedii) declined. Survey results suggested that walleye (Sander vitreus) and yellow perch (Perca flavescens) experienced moderate exploitation but benefited from recent strong recruitment and faster growth. Mechanisms underlying declines of northern pike and cisco were not clear. Despite these challenges, the St. Marys River fish community appears remarkably stable. We suggest that managers insure that creel surveys occur simultaneously with assessments, but periodic gill net surveys may no longer provide adequate data in support of recent, more complex, management objectives. *Keywords: St. Marys River, Fish populations, Monitoring.*

SCHAEFFER, J.[1], ROSEMAN, E.F.[1], and FIETSCH, C.[2], [1]USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105; [2]Bruce Power, Tiverton, ON, ON NOG2TO. **Deepwater sculpin (Myoxocephalus thompsonii) ecology at extreme depths in Lake Huron.**

We investigated deepwater sculpin (Myoxocephalus thompsonii) ecology in Lake Huron at depths of 110-190 m that had been unsampled previously. Beyond 91 m, deepwater sculpin dominated the demersal fish community, and shared the habitat with few other species. Below 175 m, the demersal fauna was exclusively deepwater sculpin and burbot. Deepwater sculpin density within the 91-190 m depth range was 0.79 individuals/m2; we found no significant density differences among depths, sites, or years. Both age-0 and yearling and older deepwater sculpin were collected from the 91-150 m depth range, but only larger and presumably older fish were present at 175-190 m. Deepwater sculpin preyed on the amphipod Diporeia, but fish at deepest sites appeared to be food limited; lower numbers of Diporiea were consumed, and condition was lower. Lake Huron's main basin still supports a large deepwater sculpin population, butthey have experienced range contraction and reduced densities in the shallow portion of their bathymetric distribution (73-110 m), and the deeper portion of their bathymetric distribution that we sampled (110-230 m) is likely now poor habitat due to low abundance of Diporiea, their preferred prey. *Keywords: Spatial distribution, Fish populations, Lake Huron.*

SCHAROLD, J.V., YURISTA, P.M., KELLY, J.R., and CORRY, T.D., US EPA Mid-continent Ecology Division, 6201 Congdon Blvd., Duluth, MN, 55804. **Benthic Macroinvertebrate Assemblages in the Near Coastal Zone of Lake Erie.**

Benthic macroinvertebrate assemblages have been used as indicators of ecological condition because their responses integrate localized environmental conditions of the sediments and overlying water. Assemblages of benthic invertebrates in the near coastal region are of particular interest, because they are expected to be the first impacted by anthropogenic stressors, and effects are expected to be greatest in that region. We conducted a survey of benthic invertebrates in the US shallow near shore zone of Lake Erie during August 2009. Forty five sites were selected in the region 0-5 km from the shoreline using a probability-based survey design. Benthic macroinvertebrates were

collected using a standard Ponar grab. The dominant taxonomic group was dreissenid mussels, with a mean density of 8054 ± 1969 (SE) m^{-2}. Other major taxa included oligochaetes (2636 ± 540 m^{-2}) and chironomids (793 ± 186 m^{-2}). Mean density of the burrowing mayfly *Hexagenia* was 113 ± 51 m^{-2}. Correlation of benthic invertebrate assemblage metrics with landscape measures of anthropogenic stress in the adjacent coastal watersheds will be analyzed using multivariate stepwise regressions.
Keywords: Coastal ecosystems, Lake Erie, Benthos.

SCHEELK, B.[1], ANDERTON, J.B.[1], LENTERS, J.D.[2], and VAN CLEAVE, K.[2], [1]Department of Geography, Northern Michigan University, Marquette, MI, 49855; [2]School of Natural Resources, University of Nebraska-Lincoln, Lincoln, NE, 68583.
Quantifying the seasonal and diurnal "lake effect" of Lake Superior: A year-round comparison between onshore and offshore meteorological conditions near Marquette, Michigan.

Lake Superior, the largest freshwater lake in the world by area, plays a major role in determining the local and regional climate. To investigate lake-climate interactions on this large body of water, a comprehensive, year-round meteorological station was deployed in the summer of 2009 on Granite Island (five miles offshore and 12 miles north of Marquette, Michigan). In the present study, we examine the seasonal and diurnal "lake effect" of Lake Superior by comparing hourly mean data collected on the island during 2010 with measurements from a nearby, land-based National Weather Service station. We find that, while the island is much more exposed to storms and high winds (on account of its offshore location), it is also much less susceptible to the dramatic warming and cooling cycles that often occur on land. Summer conditions on the island are generally windier at night and cooler during the day, with much less diurnal variation than is observed on land. The wintertime lake effect is found to be even more dramatic, with both maximum and minimum air temperatures being consistently higher than those measured on land. Finally, we note that warm-season rainfall rates show the least agreement of all variables measured at the two stations, particularly on daily or shorter timescales. *Keywords: Atmosphere-lake interaction, Lake Superior, Observing systems.*

SCHMITT MARQUEZ, H.S.[1], CHAPRA, S.C.[2], and DOLAN, D.M.[1], [1]University of Wisconsin - Green Bay, Natural and Applied Sciences, Green Bay, WI, 54311; [2]Tufts University, Civil and Environmental Engineering, Medford, MA, 02155. **Chloride and Total Phosphorus Interlake Load Estimates in the Upper Great Lakes System, 1994 - 2008.**

The Great Lakes Water Quality Agreement (GLWQA) established effluent limits and target loads for phosphorus in the Great Lakes to reduce loading and eutrophication (1972, 1978). The Upper Lakes Reference Group was appointed by the International Joint Commission (IJC) to conduct a comprehensive research study on Lakes Superior and Huron, and submitted an extensive multi-volume report that included interlake transport loads. The current research results, analyzed using data analysis and modeling methods,

showed that during 1994 - 2008, Lakes Superior, Huron, and Saginaw Bay exceeded their target loads at least once, while Lake Michigan remained below its target. Updated interlake total phosphorus load estimates showed overall decreasing trends between all lakes, but most notably from Lake Huron to Lake Erie, which steadily declined to 378 MTA in 2008, a decrease of 702 MTA from the load reported by the IJC in 1977 (1,080 MTA). Lake Superior total phosphorus loading to Lake Huron increased by 54 MTA, while Lake Michigan loading to Lake Huron decreased by 8 MTA from 1994 - 2008. Chloride interlake transport showed a 1 MTA decrease in Lake Superior loading, a 64 MTA decrease in the Lake Huron load, and a 243 MTA increase in Lake Michigan loading. *Keywords: Mass balance, Phosphorus, Water quality.*

SCHOCK, N.T., UZARSKI, D.G., COULTER, D.P., and WEBSTER, W.C., Institute for Great Lake Research and Department of Biology, Central Michigan University, Mt. Pleasant, Mi, 48858, US. **Impacts of Anthropogenic Disturbance on Macroinvertebrate and Fish Populations in Great Lakes Coastal Wetlands.**

Great Lakes coastal wetlands experience long term water level changes. During times when lake water recedes below normal levels, areas that were previously inundated are left exposed. This often prompts riparian property owners (private and public) to manipulate wetland structure and fragment wetland habitat. Channel dredging and vegetation removal are easily exercised under these conditions. We sampled wetlands immediately adjacent to boat channels and compared these disturbed sites with reference sites located 200 to 500m from each disturbance. Fish and invertebrates were sampled from disturbed and reference sites using fyke nets and dip nets respectively. We hypothesized these habitat alterations would have significant impacts on the fish and invertebrate communities that live in these near shore areas. Physical/chemical characteristics were kept consistent in order to isolate the disturbance as the responsible component for biotic change. We found that certain fish species tend to respond to the benthic structure or edge effect provided by the channel. Relationships between invertebrate species and habitat structure were also observed. Conclusions from this study will help wetland managers understand how anthropogenic disturbance potentially changes habitat structure and the biotic communities found in these areas.
Keywords: Coastal wetlands, Fish, Macroinvertebrates.

SCHREINER, D.R.[1] and EBENER, M.P.[2], [1]Minnesota Department of Natural Resources, Lake Superior Fisheries Area, 5351 North Shore Drive, Duluth, MN, 55804; [2]Chippewa/Ottawa Treaty Authority, 179 West Three Mile Road, Sault Ste. Marie, MI, 49783. **Establishment of a Commercial Siscowet Fishery in Lake Superior: Considerations, Concerns and Consequences.**

Siscowets represent the most abundant predator in the Lake Superior fish community. This fat-bodied strain of lake trout inhabits the deep-water areas of the lake (>100m) and accounts for up to 80% of the lake trout biomass. Limited management attention has been directed toward the siscowet fishery in Lake Superior. In the early

1900s siscowet were mainly harvested as by-catch in the commercial lean lake trout fishery. Beginning in the mid-1950s, commercial interest shifted to harvesting siscowet when the lean lake trout commercial fisheries were curtailed due to overexploitation and sea lamprey predation. Recently there has been a renewed interest in establishing a commercial fishery for siscowet that would target them for Omega-3 oils. In 2009, a workshop sponsored by Michigan Sea Grant brought together fishery biologists and commercial operators to explore questions surrounding the establishment of a commercial siscowet fishery. Issues that must be addressed before a commercial fishery is implemented include: biomass estimates of siscowet, development of a total allowable catch model, the role of siscowet in nutrient cycling, and reproductive capacity under conditions of exploitation. Management issues that must be addressed include harvest regulations, bi-catch, and allocation among commercial operators. *Keywords: Fish management, Siscowet, Lake Superior, Commercial fishery, Lake trout.*

SCHULDT, J.A., University of Wisconsin Superior, Superior, WI, 54880.
Morphological differences between lean and siscowet lake trout (Salvelinus namaychush) morphotypes in Minnesota waters of Lake Superior.

Quantifying the differences between lean and siscowet lake trout morphotypes is important to understanding deepwater food webs and potential exploitation of different morphotypes in Lake Superior. Lean and siscowet morphotypes were collected during a Minnesota Department of natural Resources siscowet gill net survey conducted during the summer of 2006. All fish were photographed using digital photography. A whole body morphometric analysis was used to quantify variations in body shape based on 32 truss elements using a standard truss protocol. Linear regression was used to standardize each truss element for fish size. Stepwise discriminant function analysis was used to determine important distinguishing variables between lean and siscowet morphotypes. Seven truss elements that differentiated groups were identified during the stepwise procedure. A discriminant function including these truss elements had a cross validated error rate of 16%. Our results demonstrate that these morphotypes can be quantitatively distinguished with high accuracy using image analysis and discriminant function analysis. *Keywords: Lake trout, Lake Superior.*

SCHULDT, N.J.[1], COLEMAN, J.[2], and RIPLEY, M.[3], [1]Fond du Lac Reservation Environmental Program, 1720 Big Lake Road, Cloquet, MN, 55720; [2]Great Lakes Indian Fish and Wildlife Commission, 550 Babcock Dr., Madison, WI; [3]Chippewa Ottawa Resource Authority, 179 West Three Mile Road, Sault Ste. Marie, MI. **Mining in the Lake Superior Basin: Tribal Agencies Collaborate to Protect Resources of Cultural Importance.**

The Chippewa Ottawa Resource Authority (CORA), the Great Lakes Indian Fish and Wildlife Commission (GLIFWC), the Fond du Lac Band of Lake Superior Chippewa (FDL) and other tribal agencies have responded to the massive expansion of ferrous and sulfide mining in the Lake Superior Basin with significant efforts aimed at protecting essential cultural/natural resources from contaminants, habitat degradation, and hydrologic disruption. Concerned about cumulative impacts to air, water, wetlands, forests, fish, wildlife, and traditional plants, tribes have extensively collaborated with USEPA to develop a cumulative impacts analysis protocol. This analysis can be geospatially specific, and continuously updated to provide an important perspective to NEPA analyses for current and future proposed projects. Tribes have also worked within existing frameworks such as the Lake Superior Binational Program to begin to acquire critical new baseline monitoring data in key watersheds. Finally, tribes are actively advocating for adequate data and scientifically rigorous analysis in the prediction of impacts to tribally important resources during the environmental review and permitting processes. *Keywords: Lake Superior, Spatial analysis, First Nations.*

SCHULZ, T.S., HU, D., THORNE, P.S., and HORNBUCKLE, K.C., 4105 Seamans Center for the Engineering Arts and Sciences, Iowa City, IA, 52245. **Comparison of indoor PCB air contamination with outdoor air in East Chicago, IN and Columbus Junction, IA.**

We have deployed and collected polyurethane foam based passive samplers (PAS-PUF) at residential homes in two communities: East Chicago, Indiana and Columbus Junction, Iowa. At each residence, a sampler was deployed inside the home and outside the home. The samples have been extracted and analyzed for the full suite of polychlorinated biphenyls (PCBs). In East Chicago, 272 home samples have been collected. In Columbus Junction, 455 home samples have been collected. In both communities, high-volume air samplers were also deployed at the school locations. Higher levels were expected to be found in East Chicago compared with Columbus Junction due to a higher level of current and historical industrial activity in Northwest Indiana relative to rural Iowa. However, preliminary results indicate that the two communities do not have statistically significant differences in outdoor air concentrations. The indoor air concentrations, however, are significantly higher in both communities. Congener distributions are examined to elucidate sources of PCBs from building materials and/or nearby industrial activity. *Keywords: PCBs, Airsheds, Urban areas.*

SCHWAB, D.J., NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Road, Ann Arbor, MI, 48108. **An Examination of Winds and Waves on Lake Superior Associated with the Wreck of the Edmond Fitzgerald on November 10, 1975.**

The Regional Atmospheric Modeling System (RAMS) version 4.4 was used to simulate atmospheric conditions over Lake Superior during the storm associated with the sinking of the Edmund Fitzgerald in 1975. The run spanned 54 hours, from 00Z, 9 November 1975 - 06Z, 11 November 1975. The NCEP/NCAR Reanalysis was used for initial and boundary conditions for the run. The RAMS model had 6-hour temporal resolution, grid spacing of 2.5 x 2.5 degrees, and 17 vertical levels. The sinking of the

Fitzgerald occurred approximately 48 hours into the model run, at 0015Z, 11 November 1975. Since there were almost no wave observations in Lake Superior at this time, computer model simulations of the case have also been run using the GLERL/Donelan wave model to estimate the possible wave conditions experienced during the time of the Fitzgerald's sinking. A computer animation of the results shows an area of waves with maximum significant waveheight greater than 7.5 m occurred in eastern Lake Superior at almost exactly the time the Fitzgerald was lost. From the meterological simultaion and the wave model run, it appears that the Fitzgerald could not have been in a worse place at a worse time. *Keywords: Lake Superior, Computer models, Waves.*

SCOTT, C.E. and CYR, H., Department of Ecology and Evolutionary Biology, University of Toronto, 25 Willcocks St., Toronto, ON, M5S 3B2. **Wind Driven Disturbance Impacts Benthic Primary Production.**

Waves impacting the shore move sediment as well as the benthic algal cells living in and on these sediment particles, often burying these cells. The objective of this study is to determine how this type of disturbance, along with several other environmental factors, affects benthic primary production. We looked at primary production on soft sediments at 34 sites in Lake Opeongo, a large (5800 ha), oligotrophic Canadian Shield lake in Ontario. We measured disturbance as the effective fetch in the direction the wind was blowing, multiplied by the wind speed. We also recorded a suite of additional environmental factors implicated as influencing primary production: sediment type, light, and temperature, along with algal community composition and biomass. *In situ* primary production increased with increasing light and biomass, was higher in late summer than early spring and decreased with increasing wind driven disturbance. Multiple regression indicated that the best model for predicting *in situ* primary production included light and site exposure. It is well known that wind disturbance resuspends sediments, with implications for nutrient cycling and phytoplankton production, but we have shown it is also one of the most important factors influencing benthic algal production.
Keywords: Photosynthesis, Algae, Littoral zone.

SEAMAN, L.M., Council of Great Lakes Governors, 20 N. Wacker Dr., Suite 2700, Chicago, IL, 60606. **Developing a Cumulative Impact Assessment for the Great Lakes Basin.**

In 2005, the Great Lakes Governors and the Premiers of Ontario and Québec signed the Great Lakes--St. Lawrence River Basin Sustainable Water Resources Agreement. Additionally, the Governors endorsed the interstate Great Lakes--St. Lawrence River Basin Water Resources Compact which became law on December 8, 2008. This presentation focuses on efforts to assist State and Provincial staff with meeting the commitments of the Agreement and Compact. Specifically, the Council of Great Lakes Governors is working with water managers and Great Lakes--St. Lawrence River organizations to assess individual and cumulative impacts of water withdrawals, consumptive uses and diversions. The presentation will discuss the tools and processes to be used for these assessments. *Keywords: Assessments, Hydrologic budget, Great Lakes basin.*

SEIDER, M.J.[1], OGLE, D.H.[2], and CHONG, S.C.[3], [1]Wisconsin Department of Natural Resources, 141 South Third Street, Bayfield, WI, 54814; [2]Northland College, 1411 Ellis Ave, Ashland, WI, 54806; [3]Ontario Ministry of Natural Resources, 1235 Queen Street East, Sault Ste. Marie, ON. **Age, growth and maturity of siscowet lake trout in Lake Superior, 1994-2007.**

Siscowet lake trout have increased dramatically since the early 1990s becoming the dominant predator in the offshore waters of Lake Superior. Little is known about their life history since they generally inhabit waters greater than 75 m in depth. Renewed interest in a commercial siscowet fishery for omega-3 fish oil however demands a further examination of their biology. Our objective was to describe potential trends in age distribution, growth/condition, and maturity of siscowets in Lake Superior. Similar to lean lake trout, siscowets can be very long lived (>40 years old). The von Bertalanffy parameter estimates indicated that siscowet growth may be stable or gradually declining in portions of the lake. Their condition varied between management units and may be changing over time. Potential declines in growth and condition in portions of Lake Superior were likely related to increased siscowet abundance. We found that siscowets grow slower and mature at an even later age than lean lake trout, suggesting even more conservative management will be necessary to maintain sustainable populations. Furthermore, these findings may be important when considering potential rehabilitation of deepwater fish communities in the lower Great Lakes. *Keywords: Trout, Fish management, Lake Superior.*

SERVEISS, V.B.[1], WEINER, J.[2], and GANNON, J.E.[3], [1]International Joint Commission, 2000 L Street, NW #615, Washington, DC, 20036; [2]International Joint Commission, 234 Laurier Avenue West, 22nd Floor, Ottawa, ON, Canada, K1P 6K6; [3]International Joint Commission, 9211 Huron River Dr., Dexter, MI, 48130. **The International Joint Commission 15th Biennial Report on Water Quality.**

The International Joint Commission provides advice and recommendations to help the United States and Canada in their efforts to protect and restore the physical, chemical, and biological integrity of the Great Lakes. The Commission carries out its responsibilities under the Great Lakes Water Quality Agreement with the help of five scientific boards and task forces consisting of experts from Canada and the United States. Under the Agreement, the IJC is tasked to produce biennial reports to the governments on progress toward meeting the objectives of the Agreement. For the period 2007-2009, the Commission's Great Lakes Boards developed a nearshore framework and studied five important issues related to that framework: eutrophication, beaches and recreational water quality, chemicals of emerging concern, risks and benefits of consuming Great Lakes fish; and binational rapid response to aquatic invasive species. The Commission used the results of these studies, along with additional information it compiled, to

develop its 15th Biennial Report, which it expects to release in late February 2011. In the report, the Commission presents 32 environmental policy recommendations primarily for the governments of United States and Canada and also relevant to government departments and agencies and to other environmental organizations.
Keywords: Environmental policy, Great Lakes basin, Water quality.

SHARMA, S.[1], MAGNUSON, J.J.[1], CARPENTER, S.R.[1], and SPINNER, S.[2], [1]Center for Limnology, University of Wisconsin-Madison,, 680 North Park Street, Madison, WI, 53706, US; [2]Department of Physics, University of Wisconsin-Madison, Madison, WI, 53706, US. **Temporal Dynamics In Lake-Ice Breakup Dates Around The Northern Hemisphere From 1903 To 2003.**

Ice break-up dates and other changes in lake-ice dynamics have occurred around the Northern Hemisphere in response to changing climatic conditions over the past 150 years. We investigated the temporal patterns in annual ice break-up dates with 42 lakes around the Northern Hemisphere between 1903 and 2003. We analyzed the contributions of long-term directional climate change and cyclical global climate dynamics, such as the North Atlantic Oscillation (NAO) and Southern Ocean Index (SOI). Time-series analyses were used to model temporal dynamics in an effort to i) disentangle the relative contribution of linear trends and cyclical patterns, and ii) identify the time-scales on which these processes influenced ice conditions. A combination of global climate and weather patterns acted at a variety of scales (including the 2-3, 5, 11, and 34 year cyclic dynamics) corresponding to teleconnection patterns, such as the quasi-biennial, SOI, sunspot, and AMO cycles. In addition, linear decreases in ice break-up dates attributed to longer-term climatic change, also explain the variation in ice break-up dates through time. Changes in regional and global meteorological patterns could result in continued earlier ice break-up dates leading to changes in aquatic ecosystems. *Keywords: Climate change, Lakes, El Nino, Northern Hemisphere, Ice.*

SHERMAN, J.J.[1], UZARSKI, D.G.[2], ZANATTA, D.T.[1], WOOLNOUGH, D.[1], and MURRY, B.A.[1], [1]CMU Institute of Great Lakes Research, Department of Biology, Central Michigan University, Mount Pleasant, MI, 48859; [2]CMU Institute of Great Lakes Research, CMU Biological Station Beaver Island, Department of Biology, Central Michigan University, Mount Pleasant, MI, 48859. **What Defines a Refuge for Unionids from Dreissenid Mussels (*Dreissena polymorpha* and *D. bugensis*) in Great Lakes Coastal Wetlands?**

Coastal wetland sites around Michigan were studied to locate refuge populations of native unionids, whose numbers have declined drastically since the introduction of invasive dreissenid mussels (*Dreissena polymorpha* and *D. rostriformis bugensis*) into the Laurentian Great Lakes in the mid-1980's. Physicochemical parameters and water level fluctuations were measured in the coastal wetland sites, along with the colonization rates of dreissenids, in order to determine if relationships exist between refuge populations of native unionids and these factors. Dreissenid colonization was evaluated in

each wetland using artificial substrates and dreissenids were also enumerated from the unionids surveyed. Live unionids were found in wetlands in the Les Cheneaux Islands in Lake Huron, the Lake St. Clair delta, and North Maumee Bay in Lake Erie. Significant differences in some physicochemical characteristics were noted in some of the regions surveyed. *Dreissena polymorpha* colonization densities were as high as 31,000 per m^2 at one site in North Maumee Bay, and 20,231 per m^2 in Saginaw Bay but no colonization occurred in the wetlands of the Beaver Island archipelago, the Les Cheneaux Islands, or Grand Traverse Bay sites though their presence in the open water regions of these sites was noted. *Keywords: Unionids, Refugia, Coastal wetlands.*

SHMAGIN, B., South Dakota State University, Brookings, SD, 57007. **The Issue of Uncertainty for the River Watershed: Data Analysis of Scaled Space and Time Variability.**

The issue of uncertainty is the basis for any application of knowledge ("Uncertainty is an attribute of information." From L. Zadeh, 2005) and has to be one of the main tasks in Earth's systems study. Knowledge about natural systems may be only obtained by the analysis of the empirical (instrumental) data. Uncertainty starts from unveiling of the research task by the researcher. The main source of uncertainty comes from the natural system "extraction" (unit's boundaries) for modeling and limitations of data representing both time and space variability. The consideration of uncertainty is placed in context of time and space with use of the U.S. part of the Great Lakes watershed as an example. All possible empirical (instrumental) data were used for this research. Data analysis was completed for river discharge, precipitation and air temperatures. Results of data analysis provide a base for regionalization, a multi-scaled description of the structure of river watersheds and their interaction with climate characteristics, and uncertainty of the obtained knowledge. The consideration of uncertainty in research helps practical applications like water balance estimations for conservation and/or management of water resources of different scales, and educating the public/communities about environmental issues. *Keywords: River Watershed, Data Analysis, Uncertainty.*

SHTARKMAN, Y.M., EDGAR, R.E., MORRIS, P.F., and ROGERS, S.O., Bowling Green State University, Bowling Green, OH, 43403, USA. **Metagenomic analysis of ice from the Central Basin of Lake Erie.**

The American Great Lakes hold more than 20% of the fresh surface water on Earth. From summer to winter, the taxonomic composition of the microbial communities changes. The microbes that flourish during the winter have effects on the lake during other seasons. Lake Erie is one of the largest freshwater lakes that is completely covered with ice during winter time, and the only Great Lake completely covered in the winter. Published studies indicate that there is a significant depletion in dissolved oxygen during the summer that may be caused by microbes whose numbers are high during the winter. We have completed a metagenomic study of a Lake Erie ice sample collected in the middle of the lake. We identified many sequences from the γ- and β-proteobacteria. Many representatives of Actinobacteria, Acidobacteria were found. Fewer representatives were shown to be closely related to the Planctomycetes, Bacteriodetes, δ-proteobacteria and Verrucomicrobia. Several SSU rDNA sequences obtained from this study indicated the presence of nitrite-oxidizing bacteria and ammonium oxidizing proteobacteria. In addition to organisms that are native to the lake, many signatures of human habitation were observed, including microbes common in sewage, agricultural runoff, waste water from energy generating plants and others. *Keywords: Lake Erie, Metagenomics, Microbiological studies, Phylogenetic analysis.*

SHUCHMAN, R.A.[1], LESHKEVICH, G.[2], SAYERS, M.J.[1], JOHENGEN, T.[3], and BROOKS, C.N.[1], [1]3600 Green Court, Suite 100, Michigan Tech Research Institute, Ann Arbor, MI, 48105; [2]4840 S. State Rd., NOAA Great Lakes Environmental Research Lab, Ann Arbor, MI, 48108; [3]4840 South State Street, Cooperative Institute for Limnology and Ecosystems Research, Ann Arbor, MI, 48108. **Satellite Based Retrievals of Chlorophyll, Dissolved Organic Carbon and Suspended Minerals for each of the Great lakes.**

Michigan Tech Research Institute (MTRI) scientists have modified a Nansen International Environmental and Remote Sensing Center (NIERSC) algorithm to retrieve concentrations of chlorophyll (chl), dissolved organic carbon (doc), and suspended minerals (sm) for the Great lakes using MODIS and MERIS electro-optical satellite data. The original algorithm based on a hydro-optical (HO) model of Lake Ontario generated over 30 years ago has been updated using a comprehensive set of measured Inherent Optical Properties (IOPs) coincident with in situ properties of each Great Lake collected by Great lakes Environmental Research Laboratory (GLERL) and Upstate Freshwater Institute (UFI) scientists on cruises spanning the years 2007 to present. The new algorithms based on a unique HO model for each lake achieve the desired accuracy within 10% when compared to near coincident in situ measurements. Comparisons of the five new HO models provide insight into the ecosystems of each lake and comparison with the original lake Ontario HO model indicate how that lake has changed over that period due to climate change, anthropogenic forcing, and invasive species.
Keywords: Remote sensing, Satellite imagery, Dissolved organic matter, Hydro-optical, Phytoplankton, Chlorophyll.

SIERACKI, J.L. and BOSSENBROEK, J.M., University of Toledo, Toledo, OH.
Modeling the Spread of Viral Hemorrhagic Septicemia Virus (VHSV) by Within Great Lakes Shipping.

Shipping within the Great Lakes is considered an important vector for the spread of invasive species, though it has rarely been quantified. We have built three spatial models to identify the possible role shipping has played in spreading an invasive species, viral hemorrhagic septicemia virus (VHSV), within the Great Lakes. Each model consists of a long-distance spread component, via ships, and local spread from the point of infection. The random model randomly selects six points/yr within the Great Lakes as VHSV infection points. The random ballast water discharge model selects six ballast water discharge points/yr. The nonrandom ballast water discharge model selects discharge locations based on a binomial distribution with the probability of infection being the percent of discharge received and the number of trials being the number of boats discharging at the port. The local spread simulates the spread of the disease via water and infected fish. The random model with a local spread of 10-km was least effective at predicting past reported VHSV occurrences (15.6%), and the random discharge model with a 20-km local spread was most accurate (59.1%). This suggests that while within lakes shipping plays a role in spreading invasive species, additional information is needed to refine the models. *Keywords: Invasive species, Ballast, Model studies.*

SIERSZEN, M.E., HOFFMAN, J.C., PETERSON, G.S., and COTTER, A.M., US EPA MidContinent Ecology Division, 6201 Congdon Blvd., Duluth, MN, 55804. **Stable isotope tracers of process in Great Lakes food webs.**

Stable isotope analyses of biota are now commonly used to discern trophic pathways between consumers and their foods. However, those same isotope data also hold information about processes that influence the physicochemical setting of food webs as well as biological processes operating within them. Food web baselines reflect a blend of natural and anthropogenic influences at local, landscape, and continental scales. In turn, spatial gradients in isotope ratios can be used to reveal phenomena such as horizontal and vertical patterns in animal movement and multisystem support of biota. We will use data gathered from Great Lakes food webs to explore these concepts. *Keywords: Food chains.*

SILBERNAGEL, J.[1], SMITH, V.[1], and DREWES, A.[2], [1]Nelson Institute for Environmental Studies, UW-Madison, 550 N. Park St., Madison, WI, 53706; [2]Bemidji State University, Bemidji, MN. **Spatial Narratives of the St. Louis River Estuary: Connecting Science to Spatial Literacy and Stewardship.**

The NOAA Sea Grant Program plays a significant role in promoting education, outreach and stewardship in Great Lakes coastal communities and environments. The St. Louis River Estuary, a recently designated National Estuarine Research Reserve, is particularly targeted to provide a wide range of freshwater estuarine research and education activities, including increased public awareness of the estuary's ecological and cultural significance. Through integrated socio-environmental research and design, we offer new outreach tools to enhance the Sea Grant's objectives for the LS-NERR. We illustrate the use of spatial narratives as socially and spatially rich tools for meeting these objectives through a joint WI/MN Sea Grant project. Our research connects aquatic science research on human-based stressor gradients with spatially explicit vignettes of local resource issues and place-based challenges to enhance spatial awareness and stewardship. We will discuss our work in integrating two seasons of local informant interviews with stressor gradient and geospatial data to feed into design of innovative place-based learning, including mobile apps, geo-quests, and ship-based tours. We will conclude by arguing that spatial narratives are valid tools to capture social and spatial complexity of place for research, literacy and stewardship. *Keywords: Mobile application, Outreach, Spatial literacy, Spatial analysis, Geo-quest, Coastal wetlands.*

SIMMONS, L.J., SANDGREN, C.D., BERGES, J.A., and ENGEVOLD, P.M., University of Wisconsin - Milwaukee, Biological Sciences, Milwaukee, WI, 53211.
Interpreting phytoplankton seasonal dynamics in the Great Lakes: application of high-performance liquid chromatography (HPLC).

The seasonal dynamics of the phytoplankton community in response to nutrient availability and herbivore presence are commonly assessed using algal biomass, measured as chlorophyll a. These data allow for understanding community shifts to nutrient fluxes and food web composition, though they do not have the resolution to detect responses that may occur among taxonomic groups. In order to obtain such data, species enumeration must be done. An alternative approach to obtaining taxonomic information is high-performance liquid chromatography (HPLC) which can detect group-specific accessory pigments in addition to chlorophyll a. Here we present seasonal data for near-shore and offshore locations in Lake Michigan during the summer of 2008. Traditional chlorophyll a analyses and HPLC-detected chlorophyll a are compared to identify similar shifts in biomass at each site. HPLC analyses for the group-specific accessory pigments will be emphasized to provide further resolution of the site-specific seasonal dynamics. *Keywords: HPLCE, Pigments, Phytoplankton.*

SMALL, G.E., STERNER, R.W., FINLAY, J.C., and BROVOLD, S., Department of Ecology, Evolution, and Behavior, University of Minnesota, St. Paul, MN, 55108. **High Areal Nitrification Rates in Lake Superior.**

Nitrate concentrations in Lake Superior have increased five-fold in the past century, and the cause of this increase is the subject of current debate. Evidence from isotopic signatures of lake nitrate and from an updated lake N budget indicates that most nitrate is generated from nitrification within the lake, but data on nitrification rates in the lake are sparse. We measured nitrification rates in the western basin of Lake Superior during five cruises, from November 2009-October 2010. Using *in situ* bottle incubations at 10 depths in the water column, we measured nitrification rates by both the oxidation of N-15 ammonium and the uptake of C-14 associated with nitrification. Measured rates ranged from 0.018-0.034 $\mu M\ d^{-1}$ (N-15 method) and 0.023-0.038 $\mu M\ d^{-1}$ (C-14 method), lower than reported values from other freshwater pelagic systems. However, because of the depth of Lake Superior, areal rates are high (1440-1660 mmol N $m^{-2}\ y^{-1}$), far surpassing the total flux of N into the lake, the rate of nitrate buildup, and reported rates of nitrate uptake and denitrification. These results are consistent with isotopic evidence indicating that nearly all nitrate is produced within the lake, and suggests that nitrate sinks in the lake may be higher than previously reported. *Keywords: Biogeochemistry, Nutrients, Lake Superior.*

SMART, A.M.[1], MCNAUGHT, A.S.[1], and OGREN, S.A.[2], [1]Central Michigan University, Biology Department, Mt. Pleasant, MI, 48858; [2]Little River Band of Ottawa Indians, Manistee, MI, 49660. **Ecological Requirements of Wild Rice (Zizania sp.) in the lower peninsula of Michigan.**

Zizania aquatica and *Z. palustris* (wild rice) are historically significant aquatic plants in Michigan and were once an important component of drowned river mouth and inland wetlands throughout the state. The purpose of this study is to determine which environmental factors facilitate or inhibit wild rice growth in Michigan. Sixteen sites were selected (11 that currently have wild rice beds, 5 without wild rice). Water and sediment samples were collected from each site May-October 2010. Water samples were tested for nutrients, pH, conductivity, oxygen, and temperature. Sediment samples were tested for nutrients, particle size, size distribution, and percent organic matter. Depth variation was recorded and residential development was calculated using ArcGIS® software and data from the Michigan Geographic Library. Oxygen and Nitrogen concentrations in overlying water differed between sites with and without wild rice. Furthermore, there was a relationship between wild rice patch density and specific abiotic factors. Factors associated with growth of wild rice will help determine possible sites for successful wild rice reintroduction in the future. *Keywords: Wild rice, Habitat, Water quality.*

SMITH, D.E. and TWISS, M.R., Department of Biology, Clarkson University, Potsdam, NY, 13699. **Insight into the Seasonal Dynamics of Lake Erie: Nutrient and Phytoplankton Distribution in Lake Erie with a Focus on Winter Limnology.**

Surface water was collected across Lake Erie in February, April, and August 2010 to measure phytoplankton and water quality dynamics during the transition from winter to summer stratification. Large diatom blooms (up to 124 µg chl-a/L) were present throughout the lake during the winter. CDOM concentrations decreased eastward in spring and summer, while winter concentrations were comparable among basins. Chemical oxygen demand was positively correlated to chl-a concentration in sampled water. Eastward decline in silica concentrations was seen throughout the lake for each season; silica and chl-a concentrations were greatest in the winter and lowest in the spring. These findings suggest Lake Erie experiences high productivity during mid-winter, resulting in a less influential spring bloom. Thus, winter biomass might be a main contributor to annual accumulation of organic sediment, and play an important role in the development of hypoxic conditions in the central basin. The results strongly support the need for winter surveillance and monitoring in Lake Erie in order to fully understand nutrient and plankton dynamics. *Keywords: Chemical oxygen demand, Phytoplankton, Nutrients, Water quality, Ice.*

SMITH, S.D.P.[1], ALLAN, J.D.[1], MCINTYRE, P.B.[2], HALPERN, B.[3], MARINO, A.L.[1], BOYER, G.L.[4], BUCHSBAUM, A.[5], BURTON, A.[1], CAMPBELL, L.M.[6], CHADDERTON, L.[7], CIBOROWSKI, J.J.[8], DORAN, P.[7], EDER, T.[9], INFANTE, D.[10], JOHNSON, L.B.[11], LODGE, D.[12], READ, J.[13], RUTHERFORD, E.S.[14], SOWA, S.[7], and STEINMAN, A.D.[15], [1]School of Natural Resources & Environment, University of Michigan, Ann Arbor, MI, 48109; [2]Center for Limnology, University of Wisconsin, Madison, WI, 53706-1413; [3]National Center for Ecological Analysis and Synthesis, Santa Barbara, CA, 93101; [4]College of Environmental Science and Forestry, State University of New York, Syracuse, NY, 13210; [5]National Wildlife Federation, Ann Arbor, MI, 48104; [6]Dept. of Biology, Queens University, Kingston, ON; [7]The Nature Conservancy, Lansing, MI, 48906; [8]Dept. of Biological Sciences, University of Windsor, Windsor, ON; [9]Great Lakes Commission, Ann Arbor, MI, 48104; [10]Dept. of Fisheries and Wildlife, Michigan State University, East Lansing, MI, 48824; [11]Natural Resources Research Institute, University of Minnesota, Duluth, MN, 55811; [12]Dept. of Biological Sciences, University of Notre Dame, South Bend, IN, 46556; [13]Michigan Sea Grant, Ann Arbor, MI, 48109; [14]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 48104; [15]Annis Water Resources Institute, Grand Valley State University, Muskegon, MI, 49441. **Project GLEAM: Quantifying Expert Opinion on the Relative Impact of Stressors in the Great Lakes.**

The Great Lakes are subject to a multitude of environmental stressors associated with human activity, and their impacts vary spatially and across habitat types. The aims of the Great Lakes Environmental Assessment and Mapping Project (GLEAM) are to map the intensity of 50 individual stressors, weight them by ecological impact, and combine them into a cumulative impact map. To weight the stressors, we developed a detailed survey in which respondents rated the current impact of each stressor in different habitats. We compared responses from three stakeholder groups: researchers who published recently on relevant topics, NGO members of the Healing our Waters Coalition, and managers from government agencies. Invasive species (including mussels and fish) were rated as having the greatest current impacts. However, diverse opinions within and among stakeholder pools were apparent for other stressors. For example, researchers emphasized phosphorus loading more than did managers. Despite such differences, our survey approach provides a basin-wide, quantitative summary of expert opinion regarding the relative importance of the many stressors affecting the Great Lakes. The results of this effort will provide new perspectives for prioritizing management, restoration, and conservation activities in the Great Lakes. *Keywords: Environmental effects, Spatial analysis, Spatial distribution.*

SNYDER, R.J. and DUVAL, T.B., Biology Department, SUNY College at Buffalo, Buffalo, NY, 14222. **Evaluating Indicators of Condition in Freshwater Alewives.**

Given their broad ecological impacts, accurately predicting condition and energy dynamics of alewives remains a high priority in Great Lakes fisheries management. However, the best indicator of alewife condition has yet to be determined. Using data

from laboratory experiments, we used regression analysis to explore the ability of various standard measures to predict energy density and lipid content of alewives. Wet weight was a poor predictor of energy density and lipid content ($r^2 < 0.40$), while dry weight, Fulton's K, and percent body water were much more accurate predictors, with r^2 values ranging from 0.60 - 0.95. In some cases the power of these measures to predict energy status was reduced when alewives maintained on diets differing in nutritional quality were combined into the same data set. Our results suggest that easily measured characteristics may be feasible substitutes for more costly direct measures of energy and lipid content in alewives, but nutritional effects must be taken into account.
Keywords: Alewife, Bioenergetics, Fish management.

SORENSEN, H.[1], STEWART, R.M.[1], and SUNDELL, R.[1], [1]Lakehead University, 955 Oliver Road, Thunder Bay, ON, P7B 5E1, Canada; [2]Northern Michigan University, Marquette, MI. **Citizen-Based Monitoring in the Lake Superior Basin: An inventory of local indicators, decisions and partnerships to Enhance Lakewide Management and the International Year of Monitoring.**

The Lake Superior Basin has many stakeholders and citizen based monitoring programs focused on environmental management and restoration. The Lake Superior Binational Forum is composed of members that act as liaisons between many of these stakeholder groups and the federal government agencies responsible for coordinating the 2011 Year of Monitoring. However, little information exists about how citizen-based and government monitoring programs can be integrated to produce effective indicators for lakewide decision-making. This research explores how partnerships between stakeholders leads to improved lakewide management. We compiled a publically available inventory of Lake Superior citizen-based monitoring programs (CBMP) and developed a conceptual framework for evaluating ecosystem partnerships according to international cases. Preliminary results highlight the strengths and weaknesses of the current partnerships of CBMP and show that although many people are involved in monitoring projects systematic collaboration is needed to overcome redundancies, to develop monitoring standards, and to transfer data and knowledge throughout the basin. The role of multi-scale partnerships is of vital importance in implementing an ecosystem approach to the management of Lake Superior in 2011. *Keywords: Lake Superior, 2011 Year of Monitoring, Monitoring, Monitoring Partnerships.*

STEIN, S.R.[1], POTHOVEN, S.A.[2], ROSWELL, C.[1], and HOOK, T.O.[1], [1]Purdue University, 715 West State Street, West Lafayette, IN, 47907; [2]NOAA/GLERL Lake Michigan Field Station, 1431 Beach Street, Muskegon, MI, 49441. **Distributions, Diets and Growth of Young Walleye in Saginaw Bay, Lake Huron.**

The precipitous decline of alewives in Lake Huron has seemingly led to a dramatic increase in early life survival and subsequent recruitment of Saginaw Bay walleyes. However, the mechanisms facilitating increased early life survival of walleye have not been fully explored. Previous studies suggest that the majority of young walleye are produced, via natural reproduction, in the Tittabawasee River, but it is not clear if other habitats are presently important for reproduction. During 2009 and 2010, larval walleye were collected in various Saginaw Bay habitats using ichthyoplankton nets, while juvenile fish were collected via seining and bottom trawling. Walleye larvae were aged, and diet contents from all fish were analyzed. We observed interannual variability in spatial and temporal distributions of walleye (e.g., walleye emerged earlier during a warm year, 2010, as compared to a cold year, 2009). Based on age determinations and capture locations, we speculate that walleye are successfully reproducing in multiple habitats. Feeding strategies shifted from planktivory and benthivory to primarily piscivory by October. Young walleye in Saginaw Bay appear to benefit from a diverse set of habitats and prey types. Such diversity could temper inter-annual recruitment variability, and hence, should be a goal for managers. *Keywords: Life history studies, Trophic dynamics, Fish populations, Saginaw Bay, Lake Huron, Recruitment.*

STEINMAN, A.D.[1], OGDAHL, M.E.[1], UZARSKI, D.G.[2], COOPER, M.J.[3], and WEINERT, M.[1], [1]Annis Water Resources Institute, Grand Valley State University, Muskegon, MI, 49441; [2]Department of Biology, Central Michigan University, Mt. Pleasant, MI; [3]Department of Biology, University of Notre Dame, South Bend, IN.

Water Levels in the Great Lakes: Influence on Nutrient Release.

One of the most contentious issues facing the Great Lakes is water levels. We conducted experiments to determine the influence of water level on nutrient release dynamics. Triplicate sediment cores were collected from 5 depths (upland, land-water interface, 0.25 m below water, 0.5 m below water, and 1.0 m below water) at 8 different sites (5 eastern Lake Michigan drowned river mouth wetlands and 3 Saginaw Bay sites). Sediment cores were desiccated in a controlled environment for ~2 mo and then rewetted for 48 hr. At both the drowned rivermouth and Saginaw Bay locations, mean SRP release rates (11.3 and 37.9 mg P/m^2/d, respectively) at the upland sites were significantly greater than at any other depth (range 0.40--3.04 mg P/m^2/d). In contrast, neither ammonia nor nitrate release rates showed any clear relationship with water depth. Mean nitrate release rates were negative (net uptake) at 3 of the 5 depths in the drowned rivermouth region and at all depths in Saginaw Bay. These data suggest that water depth can influence the release of bioavailable phosphorus in coastal Great Lakes wetlands, which may in turn affect metabolism. In contrast, water depth appears to have limited affect on inorganic nitrogen flux in these systems. *Keywords: Water level, Nutrients, Coastal wetlands.*

STEPIEN, C.A., HAPONSKI, A.E., SULLIVAN, T.J., and MURPHY, D.J., Lake Erie Center and Dept. Environmental Sciences, University of Toledo, Toledo, OH, 43616.

Assessing genetic connectivity and divergence patterns of walleye and yellow perch along the Huron-Erie corridor.

Walleye *Sander vitreus* and yellow perch *Perca flavescens* are key Great Lakes sport and commercial fishes whose populations have fluctuated historically due to pollution, exploitation, and - most importantly - loss of key spawning habitat and nursery

grounds. The Huron-Erie Corridor (HEC) connects the upper and lower Great Lakes, providing important fish passage, and once housed rich spawning and nursery habitats. It became a highly degraded system due to channeling, dredging, and concrete, with devastating effects on its fish populations. The recent HEC initiative has focused on restoring fish connectivity and spawning habitat. We analyze genetic diversity, divergence, and connectivity patterns among walleye and yellow perch spawning groups across the HEC, building upon our database of 9-15 microsatellite loci for 3000+ individuals. Patterns are tested using pairwise comparisons, AMOVA partitioning, Bayesian assignment, 3-D factorial correspondence analysis, and Monmonier geographic networks. Preliminary evidence supports appreciable genetic diversity and divergence patterns among spawning groups along the HEC, suggesting that some historic stocks have persisted. We are optimistic that continued habitat restoration efforts will have important positive influence on native stocks, enhancing our fisheries.
Keywords: Walleye, Lake Erie, Yellow perch, Lake Huron, Genetics, Stock structure.

STEPIEN, C.A., MURPHY, D.J., BROWN, J.E., and SOPKOVICH, E., Lake Erie Center and Dept. Environmental Sciences, University of Toledo, Toledo, OH, 43616.
The Genetic History of the Round Goby (*Neogobius melanostomus*) Invasion.

An exotic species' genetic composition and diversity are believed to be fundamentally important to ecological success. We examine these genetic parameters over the temporal and spatial course of the Eurasian round goby's invasion of the Great Lakes. We analyze variation from mitochondrial DNA cytochrome b gene sequences and eight nuclear microsatellite loci from the original invasion location versus later spread areas, in comparison with identified native source sites in northern Black Sea Rivers (controls). Results reveal marked temporal genetic change at later spread sites, with the original colonization populations remaining more static, and native "control" populations showing no change. Overall gains in microsatellite alleles over the invasion's time course supports the "genetic supplementation" hypothesis of new propagules arriving from overseas and continued spread of alleles from the original area outward. Results also support the "genetic resistance" hypothesis for original colonization sites and native sources. In conclusion, the round goby invasion exhibits significant genetic structure, high genetic diversity (with no founder effect), and has undergone temporal change with overall gain of alleles. Genetic diversity and divergence across its invasive range likely have enhanced the round goby's ecological succes *Keywords: Fish populations, Population structure, Round goby, Genetic, Invasive species, Founding source.*

STEWART, K.M., Dept. Biol. Sci., SUNY, Buffalo, NY, 14260. **Lake Baikal.**

Roughly 20% of the Earth's freshwater is contained within the five large St. Lawrence Great Lakes of North America. The focus of the IAGLR conferences tends to be on those lakes. Thus, it is easy to forget that the volume of Lake Baikal, an ancient (20-25 million years old) tectonic and majestic lake in southern Siberia (Russia), is so great that Baikal alone could theoretically hold the volume of all five of the St. Lawrence

Great Lakes. This presentation will attempt to provide some background of historical investigations, particularly those summarized earlier by Kozhov (1963). Additionally, there will be a limited description of some of Baikal's physical (three basins each with an enormous quantity of cold deep water), chemical (compared to most North American Great Lakes, Baikal is a soft-water lake), and biological (a large proportion of Baikal's biota are endemic) conditions. Some examples of Baikal's endemic plankton, amphipods, and sponges may be available for examination. *Keywords: Biodiversity, Extreme depth.*

STEWART, R.M., NICHOLSON, A., and STRICKERT, G., Lakehead University, 955 Oliver Road, Thunder Bay, ON, P7B 5E1, Canada. **Coming Down From the Ivory Tower: Can Universities Balance the Research and Applied Governance Needs of Remedial Action Plans? A Case Study From The North Shore of Lake Superior.**

We discuss governance and the Remedial Action Plans for the North Shore of Lake Superior detailing the dynamic relationships between public, academic, and government. The paper assesses the challenges and opportunities of administering a multi-stakeholder process through an academic institution. We draw attention to the identification of impairments, decision-making, and satisfying reporting needs for distinct stakeholders. The conclusions highlight how academic institutions can increase the research capacity of government designed programs and provide a community liaison role between the government-public-private sector stakeholders. Academic institutions can draw on diverse faculty expertise about ecosystem components, provide decision-support and risk assessments to determine the status of impairments, provide alternatives for monitoring that considers Lakewide effects, remediate disputes, increase social learning for developing delisting criteria and enhancing citizen monitoring for selecting remedial actions. The challenges of coordinating the RAP are also discussed including the need to balance academic rigour and idealisms within an applied government program, overcoming discrepancies in funding timelines for government/academic/community projects, and defining public-private roles and responsibilities. *Keywords: Lake Superior, Governance, Remediation, Remedial Action Plan.*

STEWART, S.R.[1] and LUSCH, D.P.[2], [1]Michigan Sea Grant Extension, 21885 Dunham Road, Suite 12, Clinton Township, MI, 48036; [2]MSU Department of Geography, 212 Geography Building, East Lansing, MI, 48824. **COSEE Great Lakes: Scientists Who Have Made a Difference and Broadened Impacts.**

COSEE Great Lakes was created in 2005 to connect formal and informal educators, students, and the public with the science of the Great Lakes. The COSEE approach to achieving this goal involves developing partnerships among research scientists, educators, students and the public. Since 2006, COSEE Great Lakes has provided professional development opportunities to formal and informal educators throughout the Great Lakes. A key to the success of these efforts has been the collaboration with research scientists who have contributed a great deal of time and expertise to these educational opportunities. This session will review the experiences of one Michigan scientist who participated in a variety of COSEE workshops, seminars and webinars focusing on Lake Huron. In addition to looking at these COSEE experiences from a scientist's perspective, he will share his impressions on how best to prepare for working with educators, and explain how his COSEE Great Lakes collaborations have helped his work to have broader impacts. *Keywords: Lake Huron, COSEE, Environmental education, Sea Grant.*

STEWART, S.R.[1], VAIL, J.[2], KELLY, T.[3], and NUGENT, R.[4], [1]Michigan Sea Grant Extension, 21885 Dunham Road, Suite 12, Clinton Township, MI, 48043; [2]Annis Water Resources Institite, GVSU, 740 W. Shoreline Drive, Muskegon, MI, 49441; [3]Inland Seas Education Association, 100 Dame St., P.O. Box 218, Suttons Bay, MI; [4]BaySail, 107 Fifth Street, Bay City, MI, 48708. **Coordinated Lake-specific Onboard Education & Outreach: A Michigan GLRI Initative.**

Through the Coordinated Lake-specific On-board Education and Outreach Project (CLOEOP), school ship programs from the Grand Valley State University Annis Water Resources Institute (AWRI), Michigan State University's Sea Grant Extension Program (MSU), Inland Seas Education Association (ISEA), and BaySail have collaborated to develop custom-designed onboard education and outreach opportunities. Educational cruises, open houses, and workshops will be conducted on three of the Great Lakes (Michigan, Huron, and Erie) plus Lake St. Clair and the Detroit River. Our programs over a two-year span will highlight the Great Lakes Restoration Initiative, lake-specific management plans, and projects in Areas of Concern (AOCs). A Great Lakes-wide coordinated effort of this magnitude has never happened in the past. This poster session will provide participants with suggestions for best practices relating to fulfilling goals of the Great Lakes Restoration Initiative through educational collaborations.
Keywords: Lake Michigan, Lake St. Clair, Lake Huron, Lake Erie, Environmental education, Great Lakes Restoration.

STONEMAN, A.T.[1], KOCOVSKY, P.M.[1], KRAUS, R.T.[1], LEE, C.S.[2], and PLUMB, R.S.[2], [1]US Geological Survey, 6100 Columbus Ave, Sandusky, OH, 44870; [2]Oberlin College, 101 N. Professor St.,, Oberlin, OH, 44074. **Diet, Age, and Reproduction of Trout-perch in the Western Basin of Lake Erie.**

Trout-perch *Percopsis omiscomaycus* is an abundant, yet poorly understood, benthic fish found in Lake Erie. Since the last study conducted on trout-perch in the 1950s, Lake Erie has undergone major ecological changes. We evaluated the notion that trout-perch have responded to these ecological changes through changes in diet, age, and reproduction. Trout-perch were collected at 50 sites across the western basin of Lake Erie using a bottom trawl. We compared proportions of prey items in trout-perch stomachs to their occurrence in benthic samples collected at a subset of the trawl sites. Preliminary diet analyses indicate chironomid larvae and Hexagenia sp. nymphs are the most frequently consumed prey whereas chironomid larvae and gastropods account for the majority of benthic invertebrates available. Historical data revealed that 25% of trout-perch diets included gammarus, and 6% included fish. Currently, gammarus is rarely found and no fish remains have been discovered. Fecundity analysis suggests that the trout-perch may have group-synchronous development of oocytes with indeterminate fecundity. Further analyses of age class structure, growth rate, and diet are currently underway. *Keywords: Lake Erie, Trout-perch, Life history studies, Benthos.*

STOW, C.A.[1], CHA, Y.[2], NALEPA, T.F.[1], and RECKHOW, K.H.[2], [1]noaa glerl, Ann Arbor,, MI, 48108; [2]Nicholas School of the Environment, Duke University, Durham, NC.

Dreissenid mussel influences on phosphorus export from Saginaw Bay to Lake Huron.

The nearshore shunt hypothesis postulates that dreissenid mussel filtration has increased phosphorus retention in coastal areas of the Great Lakes, promoting benthic algal growth in shallow regions, and decreasing offshore productivity. Saginaw Bay is a large, shallow, nearshore area of Lake Huron that experiences high external phosphorus loads. To test the nearshore shunt hypothesis, we used a simple mass balance model to estimate phosphorus retention in Saginaw Bay from 1969-2008. Our results indicate that net phosphorus sedimentation in the bay has been fairly consistent over time, but that net sedimentation as a proportion of phosphorus loading has increased since the mussel invasion. Consequently, the mass of phosphorus exported to the main body of Lake Huron decreased following the arrival of the mussels. Additionally, phosphorus retention as a proportion of input exhibits a generally increasing relationship with mussel density. These results support of the nearshore shunt hypothesis and are consistent with the pronounced decrease in the offshore fishery that has been reported in Lake Huron. *Keywords: Dreissena, Lake Huron, Phosphorus.*

STRAILE, D.[1], KERIMOGLU, O.[1], JOHNK, K.[2], and PEETERS, F.[1], [1]University of Konstanz, Konstanz, Germany; [2]CSIRO Land and Water, Black Mountain, Australia.

Lake Temperatures as Proxies for Plankton Succession.

The seasonal course of lake water temperatures and mixing dynamics has a steering role for plankton succession. The timing of major planktonic events such as the start of the spring bloom, the timing of the clear-water phase or the timing of the breakdown of the autumn bloom are strongly related to water temperature dynamics. Consequently, we should expect that the timing of successional events exhibits clear geographical trends and will change with climate warming. Hence, the development of temperature proxies for successional events should allow predicting effects of changing temperature regimes on plankton succession. In this talk we will present such proxies and explore the possibility to use these proxies for predictions of geographical gradients and climate change impacts on plankton succession. *Keywords: Phenology, Plankton, Temperature, Climate change, Mathematical models.*

STRUGER, J.[1], GRABUSKY, J.[1], CAGAMPAN, S.[1], RONDEAU, M.[2], SVERKO, E.[1], and MARVIN, C.[1], [1]Water Science and Technology Directorate, Environment Canada, Burlington, ON, L7R 4A6, Canada; [2]Water Science and Technology Directorate, Environment Canada, Montreal, QC, Canada. **Occurrence and Distribution of sulfonylurea and Related Herbicides in Central Canadian Surface Waters 2006-2008.**

Sulfonylurea (SU) herbicides are used globally in all major agronomic crops for control of broadleaf and grass weeds during pre- and post-emergent crop production. Surface water sampling was conducted from 2006 - 2008 in the Canadian provinces of Ontario and Quebec to measure the occurrence of SUs during both base flow conditions and wet weather events. Samples were analyzed using automated solid phase extraction (SPE) extraction coupled with liquid chromatography tandem mass spectrometry (LC/MS/MS). Flumetsulam, diuron and fomesafen yielded the greatest percentages of detections; other prevalent compounds were chlorimuron-ethyl and nicosulfuron. Most SU concentrations were in the low parts per trillion (ppt) range (~1 - 10 ng/L); however, maximum concentrations of compounds such as fomesafen, linuron and diuron approached 1 μg/L. The temporal trend in SU detections showed a strong correlation with typical application periods; there was a general trend toward increasing herbicide concentrations over the growing and application season up to June-July, and subsequently decreasing from August-September. Sampling during wet-weather events indicated the potential for a wide range of SUs to be flushed from areas of application into surface waters at relatively high concentrations. *Keywords: Pesticides, Water quality, Water quality.*

STRZOK, L., WERNE, J.P., HECKY, R.E., and JOHNSON, T.C., Large Lakes Observatory, University of Minnesota Duluth, Duluth, MN, 55812. **A Sedimentary Geochemical Record of Productivity and Nutrient Trends in Lake Superior.**

Modern understanding of nutrient and productivity trends in Lake Superior is necessary to better manage the largest freshwater lake in the world. Here we present a study of 6 sediment cores taken from the Western Basin of Lake Superior. Of interest are geochemical trends that have developed along with increased population, industrialization and agriculture practices within the western Lake Superior watershed in the last 2 centuries. Analysis of sedimentary total organic carbon (TOC) and nitrogen (TON) concentrations, stable isotope values of bulk organic matter ($\delta^{13}C$ and $\delta^{15}N$), and the concentration and carbon isotope composition of n-alkanes indicate that the lake has undergone productivity changes in response to nutrient availability. Our data show that primary production in the lake has increased starting in the early 1900's reaching a maximum in the 1960's. Subsequent recovery from nutrient enrichment is observable in decreased productivity by 1980, highlighted by deceasing $\delta^{15}N$ values. Despite nitrification observed by continual increasing TON, the apparent decrease in productivity supports limited availability of phosphorus and its role as the primary nutrient limiting growth in the lake. *Keywords: Biogeochemistry, Lake Superior, Paleolimnology.*

STURTEVANT, R.A.[1], LICHTKOPPLER, F.[2], MACNEILL, D.[3], BERGERON, D.[4], CLARK, G.R.[5], HART, D.A.[6], MILLER, B.[7], PISTIS, C.[8], DOLOR, M.[9], and LUCENTE, J.[10], [1]NOAA Great Lakes Sea Grant Network, 4840 South State Road, Ann Arbor, MI, 48108; [2]Ohio Sea Grant, 99 East Erie Street, Painesville, OH, 44077; [3]New York Sea Grant, SUNY College at Oswego, Oswego, NY, 13126-3599; [4]MN Sea Grant, 147 Chester Park, 31 West College Street, Duluth, MN, 55812; [5]WI Sea Grant, University of Wisconsin-Superior, Superior, WI, 54880; [6]WI Sea Grant, UW-Madison, Madison, WI, 53706; [7]IL-IN Sea Grant, University of Illinois, Urbana, IL, 61801; [8]MI Sea Grant, 940 Monroe N.W., Suite 140, Grand Rapids, MI, 49503; [9]St Lawrence Seaway Development Corporation, U.S. Department of Transportation, 1200 New Jersey Avenue, S.E. Suite W32-300, Washington, DC; [10]Ohio State University Extension / Ohio Sea Grant College Program, One Government Center, Suite 550, Toledo, OH, 43604.
Preparing Coastal Communities for Climate Change.

Sectors involved in the construction of and planning for coastal infrastructure - such as ports, marinas, stormwater managers and community planners - need to be aware of the long-term forecasts for climate change impacts as they make decisions today that will shape this infrastructure for the next 50-100 years. We report the results of a two year effort by Sea Grant Extension to address the obstacles inherent in preparing for climate change, particularly as they are faced by ports, marinas, stormwater managers and community planners. Activities related to communication of scientific uncertainties have included a compilation of journal articles related to sources of climate science uncertainty, tools for addressing these uncertainties, climate forecasting and communication of climate change uncertainty to lay audiences. Focus groups were assembled representing shipping and marinas & stormwater managers and community planners, in both Toledo and Duluth, to better understand how members viewed their vulnerability, planning time frames and investments related to climate change. A matrix tool for assessing economic impacts of climate change to coastal infrastructure was developed. Integration of climate change thinking into Sea Grant programming has grown dramatically over the course of this project. *Keywords: Climate change, Outreach, Management.*

SULLIVAN, P.J. and RUDSTAM, L.G., Department of Natural Resources, Cornell University, Ithaca, NY, 14853. **Accounting for Uncertainty in Acoustic Estimates in the Great Lakes.**

Fish abundance and behavior can be usefully assessed using hydroacoustic remote sensing. However, the process of converting raw acoustic signals into estimates of fish abundance can be noisy and complicated. Are the methods we use to calculate mean abundances the best that is statistically achievable? If we are to put effort into increasing sample size or refining estimates, where should we focus our attention? Once we understand the uncertainty associated with a given step in the conversion process, how do we incorporate that uncertainty in characterizing the final estimates? In this paper, we develop a mechanism that is part Monte Carlo and part Bayesian to address known

sources of uncertainty in the acoustic assessment process. Estimation steps are followed sequentially from Sv to abundance and the variances are carried along through each step. The structure of the analysis facilitates examination of the effects of the various parts of the analysis on the quality of the final outputs. Acoustic scientists can use this approach to help prioritize their own research and assessment designs. *Keywords: Acoustics, Assessments, Fisheries.*

SULLIVAN, T.J., STEPIEN, C.A., and SEPULVEDA-VILLET, O.J., 6200 Bayshore Road, Oregon, OH, 43616. **Fine-Scale Population Genetic Structure of Lake Erie Yellow Perch*Perca flavescens*.**

Little is known about the relationships among yellow perch spawning groups, sites, and recruitment, whose dynamics likely influence stock structure. Genetic data offer an important tool to evaluate these relationships, which may vary across spatial and temporal scales, and are important to fishery and habitat management. Here we test these patterns among Lake Erie yellow perch (*Perca flavescens*) spawning groups, whose fishery has been influenced by unstable recruitment. Fine-scale genetic stock structure is tested using 15 nuclear microsatellite loci from 945 spawning individuals, to discern patterns and consistency among: (1) 13 primary Lake Erie spawning sites, (2) years 2001-2009 at six of these sites, (3) the sexes, (4) age cohorts, (5) lake basins, and (6) Management Units (MUs). Analysis approaches incorporate pairwise, Mantel, BARRIER, Bayesian STRUCTURE, GENECLASS assignment, hierarchical AMOVA, and CONTRIB partitioning tests. Results indicate significant genetic variation among (1) spawning groups, with (2) significant but less variation among years at a given site, and no difference (3) between sexes or (4) among age cohorts, and lack of partitioning by (5) lake basin or (6) MU. Significant variation among yellow perch spawning sites and spawning years appears important for managing stock structure. *Keywords: Genetics, Yellow perch, Fish populations, Lake Erie.*

TAILLON, K.[1], MCCHRISTIE, M.[2], and CHASE, M.[3], [1]Environment Canada, Toronto, ON, M3H 5T4; [2]Ontario Ministry of Environment, Thunder Bay, ON, P7E 6S8; [3]Ontario Ministry of Natural Resources, Thunder Bay, ON, P7E 6S8. **Status of Canada's Lake Superior Areas of Concern.**

The Canada-US Great Lakes Water Quality Agreement, as revised in 1987, required the development of Remedial Action Plans for Areas of Concern. Collaboration among many stakeholders, including federal, provincial and municipal governments, First Nations, conservation authorities, non-governmental organizations, industry, academia and local citizens has been the key to the significant progress made in restoring all of Canada's Great Lakes Areas of Concern. Together these groups have invested more than 40 million dollars over two decades for restoration activities, not including funds for infrastructure projects, in four Areas of Concern on the Canadian side of Lake Superior and one on the St. Marys River. Although the sources of industrial and municipal pollution responsible for environmental impacts are now largely controlled, each site

faces it's own challenges in reaching the "water use goals" set out through the Remedial Action Plan process. This presentation will highlight some challenges in addressing restoration in Areas of Concern and provide an overview of the status of (i) environmental impairments (ii) Remedial Action Plan implementation and (iii) development of restoration targets. *Keywords: Lake Superior, Remediation, Water quality.*

TENEYCK, M.C.[1] and BRANSTRATOR, D.K.[2], [1]University of Minnesota Water Resources Science, 1035 Kirby Drive, Duluth, MN, 55812; [2]University of Minnesota Duluth Department of Biology, 1035 Kirby Drive, Duluth, MN, 55812. **Testing Relationships Between Propagule Pressure and Establishment Success of a Non-native Species, *Daphnia magna*.**

It is widely recognized that no ballast water treatment technology can be expected to perform with 100% effectiveness all of the time, accepted standards will allow a certain level of biological pollution (viable non-native organisms) to escape in the post-treated water. The International Maritime Organization has currently recognized that no more than 10 viable organisms m^{-3}, each greater than 50 micron length in minimum dimension, may be discharged during a deballasting event. However, the efficacy of this standard has not been determined. We used *Daphnia magna* as a surrogate invader, introduced to raw Duluth-Superior Harbor water indoors in 200-L mesocosm tanks, to test its establishment success. Starting inoculation densities ranged from 0 (control) to 20 individuals m^{-3} and were followed for 8 wks four times between May-November. Criteria for assessment of establishment success was based on the densities of natural populations of native daphnid species in the Duluth-Superior Harbor collected during bi-weekly sampling surveys at 9 harbor locations in the two years preceding the experiments. Differences in growth trajectories and establishment success are discussed in relation to variation in the background (recipient) communities specific to each trial and our criteria for establishment. *Keywords: Daphnia magna, Biological invasions, Ballast.*

TEUBNER, K. and DOKULIL, M.T., University Vienna, Department Limnology, Vienna, A-1090, Austria. **Intra-annual trends in the timing of rapid spring warming induced by climate signal and its effects on phytoplankton seasonality in two alpine lakes.**

Intra-annual variability of total incoming radiation (TIR), temperature, and related variables is analysed for two European deep alpine, mesotrophic lakes for the period 1982-2002. The annual pattern is described using cumulative plots of z-scores. Here we indicate the dates of rapid warming in spring and cooling in autumn, and the time span between these two inflection points each year. The timing of the spring inflection point for water surface temperature, Schmidt stability and heat content shifted significantly by about 4 to 5 days earlier per decade. In contrast, the intra-annual shifts of autumnal inflection points become less evident. In accordance, the dates for passing spring inflection point of a respective parameter are more varying among years than those of autumnal events. A progressive lengthening of the spring to autumn period becomes evident, as e.g. the period of thermal stratification increases significantly by 5-6 days in both lakes. Alterations in the timing of spring inflection of water temperature related variables are significantly connected to the winter NAO (JF, $p<0.05$). The effects of climatic signal vanish during the course of the year and are unrelated to the decline of variables in fall. The climate effects on seasonal phytoplankton dynamics will be discussed. *Keywords: Ecosystems, Deep alpine lake, Climate change, Phytoplankton.*

THUPAKI, P. and PHANIKUMAR, M.S., Civil & Environmental Engineering, Michigan State University, East Lansing, MI, 48824. **Flow Reversals and Transport in the Nearshore Region of Lake Michigan: Observations and Numerical Modeling.**

Circulation in the nearshore region of Lake Michigan is characterized by high-frequency oscillations in flow directions (flow reversals), which are generally thought to be mainly due to changes in wind direction. In this study, we use field observations and a three-dimensional numerical model to better understand the nature and origin of these flow reversals and their influence on the transport of tracers in the nearshore region. *Keywords: Princeton ocean model, Hydroacoustics, Hydrodynamics.*

TIETGE, J.E.[1], ALWAN, A.[2], ANKLEY, G.T.[1], BRAVERMAN, C.[2], HOFF, D.J.[1], MOUNT, D.R.[1], SCHMIEDER, P.K.[1], and SMITH, E.R.[2], [1]MidContinent Ecology Division, USEPA, 6201 Congdon Blvd., Duluth, MN, 55804; [2]Great Lakes National Program Office/Region 5 USEPA, 77 W. Jackson Blvd., Chicago, IL, 60604-3511. **A Strategy to Assess the Effects of Potentially Toxic Substances in the Great Lakes.**

Evaluating the risks of toxic substances in Great Lakes aquatic ecosystems has largely taken an empirical, exposure-based approach that uses chemical monitoring. The result is an extensive record regarding the spatial and temporal status of these chemicals. However, the lack of effects data on many chemicals is an obstacle to assessing risk. Therefore, a strategy was developed to acquire and use more effects-based information to reduce the existing uncertainties. This strategy approaches the problem from three perspectives. First, effects information needs to be developed for chemicals whose presence is documented or predicted. This relies on the use of traditional empirical data and new approaches to predict and evaluate toxicity of chemicals based on enhanced knowledge of biological systems, use of sub-organismal endpoints as indicators of toxicological activity, and predictive toxicological models and methods. Second, effects-based monitoring efforts need to be developed and deployed to determine if adverse effects are occurring in the environment. Third, diagnostic approaches need to be used to determine the causal factors associated with an observed effect. This strategy complements the existing chemical monitoring data, thereby improving our ability to assess the risk of potentially toxic substances. *Keywords: Toxic substances, Environmental effects, Environmental contaminants.*

TREBITZ, A.S., KELLY, J.R., HOFFMAN, J.C., PETERSON, G.S., and WEST, C.W., U.S. EPA Mid-Continent Ecology Division, 6201 Congdon Blvd., Duluth, MN, 55804.
Early Detection Monitoring Approaches for Non-Indigenous Species in Vulnerable Great Lakes Coastal Ecosystems.

Great Lakes coastal systems are vulnerable to introduction of non-indigenous species (NIS). Early detection of NIS is desired to allow timely management response, raising the question of how to do so in a cost-effective manner. To that end we conducted intensive sampling of fish and benthos in the Duluth/Superior harbor. This system is subject to heavy propagule pressure, and we detected both old and new NIS (e.g., rainbow smelt, tubenose goby, quagga mussel, NZ mud snail). Our deliberately oversampled data provide the basis for strategy evaluation. Analyses confirm that early detection is inherently inefficient -- improved detection probability comes at significant cost. Detection probability varied substantially among NIS depending on abundance, distribution, habitat use, and gear vulnerability. Species acquisition curves and composition patterns differed among designs and gears/habitats, as did invasion "status". Monitoring for NIS should cover diverse locations and habitats, but biasing benthos sampling towards shallow/vegetated over deep/bare habitats and fish sampling towards fyke and electrofish over trawl gear can increase efficiency. Further studies are being planned, with the ultimate goal of defining monitoring designs for a broad detection network. [This abstract does not necessarily reflect U.S. EPA policy]. *Keywords: Exotic species, Detection strategies, Monitoring, Coastal ecosystems.*

TROITSKAYA, E.S., SHIMARAEV, N.M., ZHDANOV, A.A., GNATOVSKY, R.Y., IVANOV, V.G., and BLINOV, V.V., Limnological Institute SB RAS, 3, Ulan-Batorskaya st., Irkutsk, 664033, Russian. **Upwellings in the Nearshore and Offshore Areas of Lake Baikal.**

Upwellings in large lakes play an essential role in thermodynamic processes and input of nutrients into a trophogenous layer. G.Yu.Vereshchagin (1927) was the first who described upwelling in Lake Baikal. Further information on upwellings was recorded by different authors without mentioning such characteristics as upwelling spatial scales and rates of water rise. This work presents the study results of upwelling development in the nearshore and offshore areas of Lake Baikal. We analyzed detailed survey of the entire lake carried out in 2002-2010 using CTD-probe SBE-25, results of long-term (1941-2010) water temperature observations at the pier in Listvyanka (Southern Baikal), transect measurements in Listvenichnoye Bay and NOAA/AVHRR satellite data for 1996-1999 and 2002. Spatial and temporal scales of upwellings were estimated, as well as their influence on distribution of water temperature and geostrophic currents. We calculated rates of water rise in upwelling and their sinking at downwelling. Areas with most frequent development of upwelling were determined, and conditions of upwelling generation in Lake Baikal were discussed. This work was supported by RMES (GK 02.740.11.0018, P1242, zadanie RNP 2.1.1/1539, RNP 2.2.1.1/5901, REC "BAIKAL"), PFR of RAS Presidium (Project 20.11) and RFBR Grant 09-05-00222.
Keywords: Upwelling, Hydrodynamics, Lake Baikal, Water currents.

TROMP, E.A., REDISKE, R.R., and O'KEEFE, J.P., Annis Water Resources Institute, 740 W. Shoreline Drive, Muskegon, MI, 49401. **PBDEs in Lake Huron Fish.**

Polybrominated diphenyl ethers (PBDEs) are used as flame retardants on a variety of products such as textiles, building materials, electronics, furnishings and plastics. Because of their endocrine disrupting abilities PBDEs are a concern for human health. Lake Huron and the other Great Lakes fish have been shown to accumulate elevated levels of PBDEs which causes concern for people who eat fish from these areas. Largemouth bass, common carp, walleye and northern pike were collected from Saginaw Bay and the Les Cheneaux islands in Lake Huron during the summer months of 2006 and 2010. They were analyzed for 9 common PBDE congeners using GC-MS. BDE-47 was the most abundant congener for all species and at both sites. The fish from Saginaw Bay had a higher total concentration of PBDEs than the fish from the Les Cheneaux islands (p-value: 0.001). Using NMDS a difference in congener patterns was detected both between species and between the two sites (p-value: 0.001 and 0.003 respectively). This data is important to studying the effects of location, species, and diet on the total PBDE concentration and the congener patterns of different fish, as well as determining if total concentration and congener patterns differ over time. Regulation of these products is important for both human and wildlife health. *Keywords: Bioaccumulation, Polybrominated diphenyl ethers, Fish.*

TURSCHAK, B.A.[2], MOERKE, A.H.[1], and EVANS, B.I.[1], [1]Aquatic Research Laboratory and School of Biological Sciences, Lake Superior State University, Sault Ste. Marie, MI, 49783; [2]School of Freshwater Sciences, University of Wisconsin-Milwaukee, Milwaukee, WI, 53204. **Spatial and Seasonal Patterns in the Crustacean Zooplankton Community of the St. Marys River.**

Zooplankton communities of the Great Lakes have received significant attention in light of recent food web changes. No recent attempts have been made, however, to characterize the zooplankton community of the St. Marys River (SMR), the sole connecting channel between Lake Superior and Lake Huron. The purpose of this study was to provide new spatial and temporal baseline information for SMR zooplankton communities. Sampling occurred at LSSU's Aquatic Research Laboratory from 2003-2007 and at 9 coastal wetlands in 2005. Within the study period, decreased densities of daphnids and increases in other cladoceran taxa (bosminids and Holopedium gibberum) as well as increased relative densities of small cyclopoid copepods were observed. Coastal wetlands showed greater species diversity and total density than the river channel. Furthermore, both seasonal and spatial surveys yielded quite different community structure than those noted in past studies of the SMR. Temperature-zooplankton abundance relationships and near-shore community structure of Lake Superior are reflected in the SMR zooplankton community; additionally, local environmental factors including changes in production, planktivory and proximity to upstream feeder communities likely play an important role in structuring SMR zooplankton communities. *Keywords: Coastal wetlands, St. Marys River, Zooplankton.*

TWISS, M.R., SMITH, D.E., ULRICH, C., and SKUFCA, J.D., Great Rivers Center, Clarkson University, Potsdam, NY, 13676. **Nearshore water quality transitions reflect functional process zones along the International Section of the St. Lawrence River: How 2-D hydrodynamic models can be used to describe plankton dynamics in this major river reach.**

Rivers are expected to be well mixed, especially large rivers without significant tributary inputs, such as the International Section of the St. Lawrence River (ISSLR). Decrease in phytoplankton in the ISSLR upon outflow into the Thousand Islands Archipelago from Lake Ontario is attributed to grazing losses. The lowest phytoplankton concentrations are detected in the Single Thread Reach of the ISSLR, but recover in the fluvial Lake St. Lawrence (LSL) region (Twiss et al. 2010. *Hydrobiologia* 647:7-20). The recovery of the phytoplankton in LSL may be due to mixing from nearshore zones. In large rivers, mixing from nearshore to main channel streams is not immediate and horizontal gradients in water quality are usually detected downstream of tributary inputs. In the ISSLR there are very few large tributaries unlike lower reaches of the river. Therefore, nearshore influences may occur from the manifestations of small tributaries (steams versus rivers) and backwater littoral zone interactions with main channel flows. We describe a nearshore-offshore water quality survey along the entire reach of the ISSLR and discuss in relation to functional process zone descriptions made possible using the 2-D hydrodynamic model River2D. *Keywords: St. Lawrence River, Main channel, Phytoplankton, Two-dimensional hydrodynamic modeling, Littoral zone.*

TYNER, E.H.[1], BOOTSMA, H.A.[1], LAFRANCOIS, B.M.[2], DEGUIRE, L.[3], and WILCOX, E.M.[1], [1]School of Freshwater Sciences, University of Wisconsin-Milwaukee, Milwaukee, WI, 53204; [2]National Park Service, St. Croix Watershed Research Station, St. Croix, MN, 55047; [3]St. Olaf College, Northfield, MN, 55057. **Investigating Botulism Mechanisms in the Lake Michigan Nearshore: Food Web Structure and Oxygen Dynamics.**

Recent outbreaks of Type E avian botulism in northern Lake Michigan have caused high bird mortality. Beginning in 2007, we examined a widely proposed pathway involving Cladophora, dreissenid mussels, and round gobies, focusing on food web linkages and benthic oxygen conditions at Sleeping Bear Dunes National Lakeshore. Stomach content analyses indicate that small and medium size gobies eat few mussels, but mussels are prevalent in the guts of large gobies. However, stable isotope analyses indicate that growth of gobies of all sizes relies more on assimilation of soft-bodied benthic invertebrates than on mussels. These findings support the importance of invertebrates in the botulism pathway, suggesting that in addition to dreissenids, soft-bodied invertebrates should be considered as a botulism vector. The potential for invertebrates to serve as a botulism vector can be expected to depend on proximity to anoxic conditions. These conditions are most likely to be found in organic-rich sediment, where chironomids are abundant. A model of benthic dissolved oxygen dynamics suggests that anoxia can also occur within mussel beds. Preliminary data support the

model's predictions that anoxic conditions required for botulinum toxin production are confined to particular places and times. *Keywords: Food chains, Sleeping Bear Dunes National Lakeshore, Invasive species, Avian Botulism, Hypoxia.*

UZARSKI, D.G.[1], COOPER, M.J.[2], and MURRY, B.A.[1], [1]CMU Institute for Great Lakes Research, CMU Biological Station, Department of Biology, Central Michigan University, Mount Pleasant, MI, 48859; [2]Department of Biological Sciences, University of Notre Dame, Notre Dame, IN, 46556-0369. **Water Level Change and Associated Great Lakes Coastal Wetland Macroinvertebrate Community Response Independent of Shifts in Vegetation.**

The International Joint Commission (IJC) is conducting a study to determine the impacts, if any, of hydrologic alteration on Great Lakes coastal wetlands. Many studies suggest that changes in hydrology produce significant changes in macrophyte communities. However, we attempted to develop indicators of water level change based on macroinvertebrates while keeping vegetation type and depth constant. Macroinvertebrates were collected from 10 fringing wetlands of the Les Cheneaux Islands Region of N. Lake Huron from 1997-2002. During this time water levels changed approximately 1 m. NMDS and Pearson correlation were used to relate invertebrate community composition to water levels while keeping depth and vegetation type constant. Our analyses suggest that collector/gatherer Caenidae and the shredder Asellidae populations seemed to reflect the water level of the previous year. This was likely indicative of a shift from a detritus based food web when water levels increased and algal based food web when water levels decreased. With habitat, water quality, and depth held relatively constant, Great Lakes water levels still impacted invertebrate communities. Therefore, our results suggest that alterations of the natural hydrologic regimes have the potential to impact these ecosystems in ways that have not yet been explored. *Keywords: Coastal wetlands, Water level, Indicators.*

VACCARO, L.E. and READ, J., Michigan Sea Grant, 440 Church St., Ann Arbor, MI, 48103, USA. **Estimating the Number of Great Lakes Jobs and Demonstrating the Value of the Lakes.**

The Great Lakes have influenced the historical development of the region's economy and the Lakes continue to support many of our most important sectors, including tourism, transportation, and energy production. The Great Lakes provide an economic advantage to many industries by providing access to cheap transportation of raw materials, abundant clean water for manufacturing and energy production, or by moderating the climate for specialty crops along the coast. Michigan Sea Grant recently developed a method for estimating the number of jobs influenced by the Great Lakes as a way of demonstrating the importance of the lakes to our economy. This talk will explore how we identified lake-influenced industries, how we estimated the number of jobs and total payroll, and how these estimates can be used. The methodology relies on publically available, national datasets and thus can be repeated annually for individual states or the region. For example, in Michigan the number of Great Lakes jobs in 2007 was 804,000, representing 23% of Michigan's payroll, but the number of jobs has dropped by 25 percent since 2000. The economic importance of the Great Lakes further emphasizes the need to maintain water quality, healthy coastal ecosystems, recreational and commercial access to the Lakes, and a safe navigational system. *Keywords: Environmental policy, Transportation, Economic impact.*

VACCARO, L.E.[1], DINSE, K.[1], LUND, K.[2], READ, J.[1], and SCAVIA, D.[2], [1]Michigan Sea Grant, 440 Church St., Ann Arbor, MI, 48109, USA; [2]Graham Environmental Sustainability Institute, 625 E. Liberty St., Suite 300, Ann Arbor, MI, 48104, USA.
Supporting Decision-making through Research and Collaboration: An Integrated Assessment Approach.

Appropriate science-based information is not always available to guide tough environmental decisions. Developing effective solutions requires targeted research and strong collaboration among natural and social scientists, decision-makers and stakeholders. Integrated Assessment is a research approach that aims to inform policy and management decisions surrounding challenging environmental issues. Research teams work closely with policy makers to assess the issue from multiple perspectives and develop tools that can guide decision making, such as cost-benefit analyses, risk assessments and new communication strategies. This talk will highlight three recent Integrated Assessment projects that addressed Great Lakes issues: stormwater run-off, fish consumption advisories and coastal access. To evaluate the impacts, we interviewed 25 participants, including scientists, natural resource managers, private consultants, public officials and non-profit leaders. Participant comments were synthesized across the projects to identify common themes, benefits and outcomes. The interview results illustrate that projects generated both specific tangible benefits, such as useful reports, models and outreach materials, and intangible benefits, including new perspectives, partnerships, processes and opportunities. *Keywords: Integrated assessment, Environmental policy, Outreach.*

VALENTA, T.J.[1], KENNEDY, J.A.[1], DOLAN, D.M.[2], and KLUMP, J.V.[3], [1]2231 N. Quincy Street, Green Bay, WI, 54302; [2]2420 Nicolet Drive, Green Bay, WI, 54311; [3]600 E. Greenfield Ave., Milwaukee, WI, 53204. **Oxygen Depletion in Lower Green Bay.**

The Green Bay Metropolitan Sewerage District has been actively monitoring water quality trends on lower Green Bay since 1986. Data collected from continuous monitors located approximately eight miles north of the Fox River mouth in lower Green Bay indicates there are numerous times during the sampling season when the measured dissolved oxygen concentrations in the lower water column fall below the 5 mg/L standard for beneficial uses in the Area of Concern. Both a drop in temperature and specific conductance accompany the decrease in dissolved oxygen. These events are generally observed along the eastern shores of Green Bay, but have been documented moving as far south as the mouth of the Fox River. The induced period of hypoxia has been known to last from several hours to a week or more before it dissipates, typically in response to wind induced mixing. Dissolved oxygen concentrations collected by continuous monitors during the summers of 2005 and 2010 showed increased hypoxia in the lower strata of the water column, with the number of days increasing from 23% to 52% for these two particular years. Hypoxic events during the summers of 2006 through 2009 were prevalent, but not as numerous. The full extent of oxygen depletion in lower Green Bay has not thus far been thoroughly documented. *Keywords: Green Bay, Oxygen, Water quality.*

VAN CLEAVE, K.[1], LENTERS, J.D.[1], and WANG, J.[2], [1]School of Natural Resources, University of Nebraska-Lincoln, Lincoln, NE, 68583; [2]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48108.
Interactions among Lake Superior ice cover, evaporation, and water temperature: A re-examination of the standard paradigm.

The "standard paradigm" that high ice cover on lakes leads to low evaporation is often assumed, but rarely investigated. Understanding the interactions among ice cover, evaporation, and water temperature is, however, critical to predicting interannual and long-term changes in lake energy and water balances. For example, an often-overlooked factor is the negative feedback of evaporative cooling on lake temperatures. This mechanism would suggest that winters with high ice cover may actually be indicative of high evaporation during the months leading up to ice formation. Such a connection would result in an ice-evaporation feedback that is counter to the current paradigm. In the present study, we investigate the significance of this ice-evaporation feedback for Lake Superior by examining ice cover, water temperature, and evaporation records for the period 1981-2010. Interannual variations in wintertime ice cover are compared with evaporation rates and water temperature during the months leading up to ice formation and the months following spring thaw. Correlation and composite analyses are used to assess the strength of the interactions. The results show that winters with high ice cover are generally preceded by periods of high evaporation, thereby offsetting much of the (negative) ice-evaporation feedback that is often assumed. *Keywords: Lake Superior, Evaporation, Ice, Atmosphere-lake interaction.*

VAN DER WERFF, J.M., GUILDFORD, S.J., and HECKY, R.E., Large Lakes Observatory, 2205 East 5th Street, Duluth, MN, 55812. **Nutrient Status of Phytoplankton in the Deep Chlorophyll Layer (DCL) of Lake Superior during the Summer of 2010.**

The deep chlorophyll layer (DCL) is a phenomenon in which a subsurface peak of chlorophyll forms at the metalimnion and persists during stratified conditions. This layer may be more than just an accumulation of chlorophyll; preliminary data suggests that the DCL is productive. Phytoplankton in this section of the water column may play a significant role in nutrient recycling in Lake Superior. Water samples were collected above, within, and below the DCL across the lake during the summer of 2010. Chemical analyses (TP/TN, TDP/TDN, SRP, Particulate P, ammonium, nitrate/nitrite, C/N, Chl a, C/Chl a) were performed in conjunction with bioassays (alkaline phosphatase activity, N/P debt) and active fluorometry (PhytoPAM) to fully assess phytoplankton nutrient status. According to P debt and alkaline phosphatase activity, phytoplankton were nutrient deficient at all depths and stations throughout the summer with maximum deficiency occurring in the upper mixed layer. The degree and diel oscillation of nutrient deficiency in the DCL were determined to better understand lake productivity. *Keywords: Phytoplankton, Deep chlorophyll layer (DCL), Nutrients, Lake Superior.*

VANALSTINE, J.D., YURISTA, P.M., KELLY, J.R., and MILLER, S.E., USEPA MidContinent Ecology Division, 6201 Congdon Blvd., Duluth, MN, 55804. **Lake Michigan: nearshore variability.**

We conducted a high-resolution survey in the nearshore of Lake Michigan at a 20 meter contour using towed electronic instrumentation. The nearly 1200 km survey was conducted Sep 8-15, 2010. We also conducted six cross-contour tows. Along the survey tracks we sampled fixed stations (15) to collect calibration data and other parameters not observed by the in situ electronic sensors. With the towed sensor data we constructed a comprehensive representation of spatial variability in the nearshore. We analyzed for potential signals within the variability that may be correlated to landscape characteristics of the adjacent coastal watersheds using multivariate stepwise regressions. The survey provided an overview of whole lake variability in the nearshore of Lake Michigan. This abstract does not necessarily reflect USEPA policy. *Keywords: Lake Michigan.*

VANDERPLOEG, H.A.[1], POTHOVEN, S.A.[2], FAHNENSTIEL, G.L.[2], RUTHERFORD, E.S.[1], CAVALETTO, J.F.[1], LIEBIG, J.R.[1], STOW, C.A.[1], NALEPA, T.F.[1], MADENJIAN, C.P.[3], BUNNELL, D.B.[3], WARNER, D.M.[3], and PICHLOVA-PTACNIKOVA, R.[4], [1]NOAA, Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 48108; [2]Great Lakes Environmental Resarch Laboratory, Lake Michigan Field Station, Muskegon, M, 49441; [3]U.S. Gelogical Survey, Great Lakes Science Center, Ann Arbor, MI, 48105; [4]University of Oldenburg, Wihelmshaven, Germany. **Response of the Zooplankton Community to the Newly Re-engineered, Spatially Complex Lake Michigan Ecosystem: Old paradigms vs. the New Reality.**

The recent expansion of dreissenid mussels into deep water has re-engineered nutrient and carbon flows, greatly reduced the phytoplankton food base and increased light intensity. We discuss the changing roles of food limitation, invertebrate and vertebrate predation, and the potential role of light as factors causing changes in the zooplankton community. We believe light is a master variable for changing spatial coupling in the food web and altering the balance between vertebrate and invertebrate predation, especially that between the visually feeding, invasive predatory cladoceran Bythotrephes relative to planktivorous fishes. Because of the simultaneous existence of the nearshore C and P shunt and the mid-depth C and P sink, mussel engineering impacts have led to a spatially complex environment for the plankton community in both vertical and horizontal space.

VARIAN, A.M., QUINLAN, H.R., and BROUDER, M.J., US Fish and Wildlife Service, 2800 Lakeshore Drive East, Ashland, WI, 54806. **Status, Distribution and Threats to Lake Superior Brook Trout.**

Brook trout are the only stream dwelling trout native to the upper Midwest and populations of both resident and lake run coaster forms have declined dramatically since early settlement of the region; however, the extent, severity, and in some cases, the cause of the decline is unknown. Building upon work by the Eastern Brook Trout Joint Venture, current brook trout data will be used to develop a GIS based model of the status, distribution and threats at a catchment level. Recent fisheries data collected throughout Michigan's Lake Superior basin will be supplemented by field work planned for 2011. The data compiled will be used to classify all catchments with current brook trout data according to their status. Agency biologists have listed potential threats to brook trout in their region, these threats and a suite of landscape metrics will be used to develop a classification tree model to predict brook trout status in areas where data is insufficient. The result of this project will be a current map of status, distribution and threats of brook trout in Michigan's Lake Superior basin to help agencies prioritize future management actions. *Keywords: Spatial distribution, GIS, Trout.*

VERBURG, P.[1], ANTENUCCI, J.P.[2], and HECKY, R.E.[3], [1]National Institute of Water and Atmospheric Research, Hamilton, New Zealand; [2]Centre for Water Research, University of Western Australia, Perth, Australia; [3]Biology Department and Large Lakes Observatory, University of Minnesota-Duluth, Duluth, MI. **Differential cooling drives large-scale convective circulation in Lake Tanganyika.**

Field data, scaling analysis, and three-dimensional numerical experiments demonstrate that the dominant large-scale circulation pattern during the southeast trade winds in Lake Tanganyika is a downwind flow in the metalimnion, with a returning southwards upwind flow in the upper region of the epilimnion. This is in the opposite direction to prior literature on the lake, which has assumed that the southeast trade winds drive a northwards surface flow due to momentum induced by the wind. The gradient in wind speed and humidity along the length of the lake and the resulting gradient in heat exchange with the atmosphere result in warm water accumulating at the northern end of the lake. The north basin of Lake Tanganyika thus acts as a heat sink while the south basin is a net source of heat to the atmosphere. The resulting variation in buoyancy flux is strong enough to drive a convective flow in the upper layer in the opposite direction to the wind. A large-scale convective circulation results in an annual exchange of 6.2×10^{12} m^3 of water and an annual net transport of heat (averaging 0.2 TW) from the northern to the southern region of the lake. Currents in the upper 100 m layer, with a mean flow of 0.2 Sv, can be described by the superposition of a parallel convective flow with the internal seiche motion. *Keywords: Atmosphere-lake interaction, Overturning circulation, Hydrodynamics, Convective currents.*

VERHAMME, E.M., DEPINTO, J.V., and REDDER, T.M.., LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108. **Application of a Fine-Scale Ecosystem Model to Saginaw Bay, Lake Huron.**

Over the past several decades Saginaw Bay has been impacted by many stressors including: excess nutrient and sediment loads, legacy and emerging contaminants, water level changes, invasive species, and nuisance algae. Past efforts to control the stressors have dealt with them individually, without consideration of interactions among stressors. As part of a NOAA funded project we have been refining our previous ecosystem model of Saginaw Bay (SAGEM) with the development of a fine-scale, linked hydrodynamic and ecosystem model termed the Advanced Aquatic Ecosystem Model (A2EM). One of the primary advances in the new model is the coupling of the existing lower food web framework with the new Great Lakes *Cladophora* Model (GLCM) developed by M. Auer and others. Initial testing of the model focused on the early 1990's with a refinement of model calibration to data collected in 2009 and 2010 by other project members. Presented here is the model simulation results compared against field data from 2009 and 2010 as well as diagnostic applications of the model that illustrate and explain multi-stressor interactions in the system. *Keywords: Model studies, Saginaw Bay, Ecosystem modeling.*

WALKER, G., VILLENEUVE, M., and SAVIGNAC, F., Environment Canada, Gatineau, QC. **Water Conservation and Pricing in Canadian Great Lakes Municipalities (Municipal Water and Wastewater Survey data).**

The domestic sector accounted for over a third of water use in the Canadian portion of the Great Lakes watershed in 2006 (thermal power plants excluded). Domestic water use per capita was the sixth lowest out of all Canadian watersheds. This represented 55% of the water distributed by municipal water utilities in Canadian Great Lakes municipalities. Due to the large volumes involved, the promotion of the wise use of municipal water is important to help ensure that Great Lakes water remains safe and available for generations to come. Conservation measures and volumetric pricing structures are ways to promote wise water use. Water conservation measures aim to reduce water use to avoid increases in water withdrawals and expansion of water infrastructure. Volumetric pricing structures have similar aims, and it has been shown that residents use less water when they are charged a volumetric rate compared to a flat rate. The Municipal Water and Wastewater Survey (MWWS) collects data on conservation measures and pricing structures used in Canadian municipalities. In this presentation pricing structure, average cost, water meter usage and conservation measure implementation will be examined in order to comment on their impact on average municipal water use in the Canadian portion of the Great Lakes basin.
Keywords: Municipalities, Data acquisition, Water use, Management, Urban watersheds, Canada.

WALSH, M.G.[2], RUDSTAM, L.G.[1], WEIDEL, B.C.[2], LANTRY, B.F.[2], NADDAFI, R.[1], BOSCARINO, B.[1], HALPIN, K.[1], GUMTOW, C.[1], and SUN, J.[1], [1]Cornell Biological Field Station, Department of Natural Resources, Cornell University, Bridgeport, NY, 13030; [2]USGS - Lake Ontario Biological Station, Oswego, NY, 13126. **Hemimysis anomala - a new predator in the nearshore of Lake Ontario.**

Hemimysis was locally abundant along both the Canadian and US shorelines by 2008. Here we summarize the results of our investigations on this species along the south shore of Lake Ontario. Hemimysis consumed zooplankton including Daphnia, Cercopagis, Bosmina, benthic (harpacticoids) and pelagic (calanoids and cyclopoids) copepods. Diatom frustules were also common. Stable isotopes show that ingested carbon was derived from the phytoplankton and benthic algae. Hemimysis produced several generations per year and abundance varied substantially with season. Feeding rates in the laboratory exceeded 10 Bosmina per hour and they selected cladocerans over copepods. Hemimysis can be found in water depth exceeding 20 m if the bottom substrate contains rocky habitat. We predict that Hemimysis will be an abundant major zooplanktivore in rocky nearshore areas. The species represents a new ecological type (nearshore warmwater mysids) that hitherto have been absent from the Great Lakes. In Europe several nearshore mysids species coexist and we may expect additional nearshore mysids to appear in the Great Lakes. However, the largest ecological effects are likely from the first arrival in the group, in our case Hemimysis anomala. *Keywords: Biological invasions, Mysids, Lake Ontario, Exotic species.*

WALTERS, H.D.[1] and FORTNER, R.W.[2], [1]Ashland University, 401 College Avenue, Ashland, OH, 44805, United States; [2]COSEE Great Lakes, 113 Paula Circle, Oak Island, NC, 28465, US. **COSEE Great Lakes: Findings of the Evaluation Study.**

The NSF Funded Center for Ocean Sciences Education Excellence: Great Lakes has been implemented since 2006 by a consortium of partners comprised primarily of the respective Sea Grant programs from the Great Lakes States. This report provides quantitative and qualitative evidence that COSEE Great Lakes has succeeded in creating a statistically significant enhancement to the content knowledge of a cadre of formal and informal educators in the region. Additionally, these educators are demonstrating a commitment to infusing Great Lakes Literacy content and relevant science research in their instruction activities in ways that seem durable and sustainable.
Keywords: Education, Outreach, Public education.

WANG, J.[1] and BAI, X.[2], [1]NOAA Great Lakes Environmental Research Laboratory, 4840 S State Road, Ann Arbor, MI, 48018; [2]University of Michigan CILER, 4840 S State Road, Ann Arbor, MI, 48108. **Great Lakes Climate and Ice Research: Diagnosis and Modeling.**

The impacts of ENSO (El Nino and South Oscillation) and Arctic Oscillation (AO) on the Great Lakes ice cover were investigated using ice observations for winters 1963-2010, and NCEP reanalysis data. Signatures of ENSO and AO were found in the Great Lakes ice cover. However, the impacts are nonlinear and asymmetric. Strong El Nino events are often associated with least ice cover on the Great Lakes, while the impacts of weak El Nino and La Nina events on the Great Lakes are marginally significant. Negative AO events are often associated with severe ice cover, while positive AO event has smaller impact. The strong El Nino and negative AO events explained about 50% severe and least ice cover winters on the Great Lakes, respectively. The interference of the effects of ENSO and AO over the Great Lakes makes the relationships complicated. This may be an important cause of nonlinear and asymmetric responses of the regional climate including lake ice in the Great Lakes to ENSO and AO. A coupled Great Lakes Ice-circulation Model (GLIM) was implemented in Lake Erie to investigate synoptic variations and seasonal cycle of lake ice and circulation under daily and hourly atmospheric forcing. Furthermore, a 5-lake unstructured grid model is also implemented for regional climate change studies in response to large-scale climate change.
Keywords: Climatology, Ice, Model studies.

WANG, Y.Y.[1], YU, X.B.[1], LI, W.H.[1], and XU, J.[2], [1]Key Laboratory of Ecosystem Network Observation and Modeling, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, 100101, China; [2]Donghu Experimental Station of Lake Ecosystems, State Key Laboratory of Freshwater Ecology and Biotechnology of China, Institute of Hydrobiology,CAS, Wuhan, 430072, China.

Food web dynamics in Lake Poyang related to water-level fluctuation.

Nature water-level fluctuation in lakes can influence available food sources and modify trophic links in aquatic food web. Lake Poyang is the largest freshwater lake in China with a unique seasonal reverse-flow system. The averaged water level change is about 12 m between wet and dry seasons. We predicted that high water level could bring consumers more abundant food sources such as terrestrial plants, at low water periods high densities may lead to more piscivory. We therefore used stable isotopes and IsoSource mixing models to estimate contributions of different food sources, including particulate organic matter, terrestrial plant and aquatic macrophyte, to the dominant consumer at different seasons. Our results indicated that in dry season δ13C and δ15N of fishes had no significant spatial variations, and the terrestrial plant and POM were the major carbon sources for the fishes. In wet season aquatic macrophyte was identified as the most important food sources. δ13C of fish were lower but δ15N were higher in wet season than in dry season and varied spatially. The low water level at dry season may make the food sources competition more severe, leading the fish consume more terrestrial source. Contaminated water caused by floods from upstream may explain the high 15N ratio at wet season at different sites. *Keywords: Isotope studies, Food chains, Water level fluctuations.*

WARD, M.C.[1], SCHREINER, D.R.[1], and MILLER, L.M.[2], [1]MN Dept. of Natural Resources, 5351 North Shore Dr., Duluth, MN, 55804; [2]Dept. of Fisheries, Wildlife, and Conservation Biology, University of Minnesota, 1980 Folwell Ave. 200 Hodson Hall, St. Paul, MN, 55108. **An Evaluation of Coaster Brook Trout Rehabilitation Measures on the Minnesota Shore of Lake Superior.**

Coaster brook trout Salvelinus fontinalis are an ecological variant of inland brook trout that spend part of their lives in the Great Lakes. Anecdotal angler reports indicate, by the late 1800's, coaster brook trout abundance along the Minnesota shore had been substantially reduced. Populations remained low for nearly a century. A resurgence of interest by anglers and Lake Superior management agencies, led to the formation of a Brook Trout Subcommittee in 1993. This group investigated the status of coaster brook trout in Lake Superior and developed a rehabilitation plan that was published by the Great Lakes Fishery Commission in 2003. In 1997, despite heavy pressure to use stocking as the rehabilitation tool, Minnesota responded with restrictive regulations and habitat protection to enhance remaining populations. In addition, a fall electrofishing survey was initiated. Surveys were conducted in 1997, 2002, and 2007/2008. Surveys indicated a shift in the population's age-structure, size-structure, and CPE of fish greater than 356 mm (14 inches). Microsatellite genetic analysis indicated 84% of all fish sampled and 85% of fish greater than 14 inches sampled in the 2007/2008 survey were Minnesota fish and not strays from other agencies stocking programs. *Keywords: Lake Superior, Coaster brook trout, Fish management, Rehabilitation, Trout, Genetics.*

WARREN, G.J. and MAY, J.C., U..S. Environmental Protection Agency, Great Lakes National Program Office, 77 W. Jackson Blvd., Chicago, IL, 60604. **Identifying Features in the Nearshore Waters of Lake Michigan Using Towed Sensor Data.**

We are developing a nearshore monitoring program for Lake Michigan, and the other Great Lakes' using continuous, towed sensor data. Visual analysis of contour plots of towed sensor data can be used to identify features along the coastline. These features have been shown to persist in Lake Huron throughout a season when comparing towed sensor surveys separated by a month or more (Yurista, personal communication). Features appear to be associated with river mouths, and riverine input to the lakes. A foundation of the monitoring program will be development of our ability to compare towed data acquired in separate years, on a long-term basis. A September, 2009, survey of Lake Michigan, at the 20 meter depth contour, is being used to test techniques to quantify observed features. We will present the results of multivariate analyses of temperature, conductivity, beam attenuation, specific conductance, and zooplankton density acquired during the survey. Defining consistent features in the nearshore will help to identify areas that merit additional sampling or study effort, and to focus cooperative nearshore work. *Keywords: Lake Michigan, Monitoring, Water quality.*

WATKINS, J.M. and RUDSTAM, L.G., 900 Shackleton Pt Rd, Bridgeport, NY, 13030. **Evaluating the role of quagga mussel expansion on phytoplankton of Lake Ontario.**

Modest reductions in phytoplankton stocks of the lower Great Lakes during the early 1990s were attributed to a combination of lower phosphorus loading and the introduction of dreissenid mussels to nearshore habitats. The continued decline has reached levels critically low for the support of zooplankton and higher trophic levels. The recently proposed "mid-depth sink" suggests that the disappearance of the spring phytoplankton bloom in Lake Michigan in 2007 can be at least partially explained by the expansion of quagga mussels to deep water over the past decade. A similar loss of the spring bloom of Lake Huron occurred at much lower dreissenid densities. Quagga mussels were abundant at ≥ 30 m depth in Lake Ontario by 1999, much earlier than the two other lakes. We compare the trends in Lake Ontario phytoplankton stocks, using shipboard monitoring and satellite imagery, to the expansion of quagga mussels detected by lake-wide benthic surveys. *Keywords: Dreissena, Satellite technology, Phytoplankton.*

WATSON, S.B.[1] and PICK, F.[2], [1]NWRI, Water Science and Technology Directorate, Environment Canada, Burlington, ON, L7R 4A6; [2]Biology Dept, University of Ottawa,, Ottawa, ON, K1N 6N5. **Picoplankton communities in large lakes: spatial-temporal patterns across trophic and mixing regimes.**

Early studies have tenuously linked seasonal and spatial patterns in autotrophic and heterotrophic picoplankton (PP) with nutrient/light regimes and grazers. In the past few decades eutrophication/remediation, basin development and invasive species have profoundly shifted these abiotic and biotic processes in the Great Lakes and other large waterbodies, but their effects on PP have not been recently evaluated. This paper presents recent multi-year/season PP surveys in Lakes Ontario, Erie, Winnipeg and Lake of the Woods across gradients of water chemistry, nutrient, light and mixing characteristics and compare this with historical data from these and other lakes. We assess patterns in heterotrophic/autotrophic and pigment classes in relationship with depth, mixing, water quality/transparency and aesthetics (taste-odour), and also use these data to assess methodological artifacts derived from filter leakage *Keywords: Phytoplankton, Picoplankton, Microbiological studies, Large lakes, Nutrients, Light.*

WATTEN, B.[1], ADAMS, N.[2], MARKESTAD, J.[3], GREEN, P.A.[4], SMITH, S.[5], and HENQUENET, J.[4], [1]USGS Leetown Science Center, 11649 Leetown Road, Kearneysville, WV, 25430; [2]USGS Columbia River Research Laboratory, 5501A Cook-Underwood Road, Cook, WA, 98605; [3]The Gloston Associates, 1201 Wesern Avenue, Suite 200, Seattle, WA, 98101-291; [4]National Park Service, 80 East Lake Shore Drive, Houghton, MI, 49931; [5]USGS Western Fisheries Research Center, 6505 NE 65th St.,, Seattle, WA, 98115. **Active Mixing Techniques in Ballast Water Tanks.**

Field trials were conducted on the Great Lakes bulk carrier M/V Indiana Harbor in 2009, 2010 and 2011 to determine the relative efficacy of several passive and active methods for mixing chemicals in the vessel's ballast water to control non-indigenous species. Tank mixing methods are needed for treating ballast water carrying high risk nonindigenous species on ships during a casualty, such as running aground, and in regulatory interventions to high risk vessels upon arrival. The passive methods evaluated were selected based on their ability to use materials readily available from the ship's locker, while the active methods were selected based on obtaining equipment not generally available on a ship, but that would be able to rapidly mix chemicals in a full or partially full ballast tank. This presentation will focus on the active mixing methods trialed both on the ship and in preliminary tests conducted in the laboratory using 1/10 scale physical models. More specifically, we will describe the relative mixing efficiency of airlift, water eductor and water jet mixers operated in several different configurations. Mixing intensity was indicated by convergence rates of Rhodamine WT dye concentrations monitored at up to 152 locations in 6 replicate ballast tanks each with a working volume of about 900,000 gallons. *Keywords: Ballast, Invasive species.*

WEBSTER, W.C. and UZARSKI, D.G., Institute for Great Lakes Research and Department of Biology, Central Michigan University, Mount Pleasant, Mi, 48859.
Impacts of Great Lakes Water Level Fluctuations and Anthropogenic Disturbance on the Macrophyte Flora of Coastal Wetlands.

Anthropogenic disturbances such as dredging and hardening of the shoreline are major causes of wetland loss. The Laurentian Great Lakes are subject to natural water fluctuations that are crucial to the biology of the Great Lakes coastal wetlands. These fluctuations promote plant diversity and species richness, which support the health of Great Lakes coastal wetlands. Natural lake level fluctuations tend to promote development in near shore areas by dredging boat channels during low water level years or hardening the shoreline during high water level years. The integrity of the vegetation is strongly related to the wetland's structure and function. Thus, the objective of this study was to determine the affect of anthropogenic disturbance on wetland plant communities. The study was conducted by comparing areas of disturbance with intact coastal wetlands. Sampling sites were located on the northern shoreline of Lake Michigan and the western shoreline of Lake Huron. An inventory of plant taxa and accompanying physical/chemical data were analyzed to relate coastal wetland vegetation to disturbance. *Keywords: Vegetation, Coastal wetlands, Water level fluctuations.*

WEINTRAUB, L.H.[1], FLYNN, A.M.[1], SELVENDIRAN, P.[1], DEPINTO, J.V.[1], and RUPP, B.R.[2], [1]LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108; [2]USACE - New England District, 696 Virginia Rd, Concord, MA, 01742. **Evaluation of Blanchard River Watershed Sediment and Nutrient Loading Under Baseline and Improved Management Conditions.**

A watershed model was applied to quantify sediment and nutrient loading from the Blanchard River watershed, a Maumee River tributary. AnnAGNPS was adapted at a fine resolution and remote sensing data were used to define a 4 year crop/tillage rotation. Model calibration/confirmation were conducted with 15 years of observed stream flow and water quality data. Calculated annual R2 and Nash-Sutcliffe model efficiencies were 0.75 and 0.86 for direct runoff and suspended sediment simulations. Ephemeral gully erosion accounted for 85% of the total landscape erosion. Potential benefits of improved land management were evaluated. Modeled suspended sediment loading with watershed management actions include a 54% reduction with conversion of 10% of highest eroding cropland to grassland, and a 60% reduction with combined management involving conservation tillage and cropland conversion. Simulated nutrient loading reductions with improved management include a 25% reduction of phosphorus and 39% reduction of nitrogen loading with cover crops, and a 21% decrease in phosphorus and 60% decrease in nitrogen loading with fertilizer application reduced by 60%. Several areas of data and model uncertainty will be discussed such as input data sets, model formulations of ephemeral gully erosion and nutrient cycling, and model characterization of BMPs.
Keywords: Sediment load, Nutrients, Lake Erie, Modeling, Watersheds, AnnAGNPS.

WELCH, J.B., REED, A.J., and HICKS, R.E., Department of Biology, University of Minnesota Duluth, 1035 Kirby Drive, SSB 207, Duluth, MN, 55812. **Molecular Analysis of Bacterial Communities in Ship Ballast Water and the Duluth-Superior Harbor.**

More ballast water is discharged into the Duluth-Superior Harbor than any other Great Lakes port. Little is known about the bacterial communities within this harbor or ballast water, yet this information is crucial for identifying potential invasive microbes. Water was collected at six sites in Lake Superior, the Duluth-Superior Harbor, and the lower St. Louis River to characterize bacterial communities. Additional samples were collected from ship ballast water and the Western Lake Superior Sanitary District because these sources may influence the composition of natural bacterial communities. A DNA fingerprint analysis indicated bacterial communities in ballast water discharged into the harbor were often different from planktonic bacterial communities found within the harbor. Although 16S rRNA gene clone libraries of harbor and ballast water all contained bacteria in three widely distributed phyla (*Actinobacteria*, *Alphaproteobacteria*, and *Bacteroidetes*), three clonal sequences from seawater ballast were 97 percent similar to *Tennacibaculum soleae*, a potential marine fish pathogen. This example demonstrates that potentially harmful bacteria can be transported in ballast tanks of ships and points out the need to identify harmful bacteria that may be introduced into the Great Lakes.
Keywords: Invasive species, Microbiological studies, Ballast.

WELLINGTON, C.G.[1], GABRIEL, T.G.[1], KELCH, D.O.[1], BRAIG, E.C.[1], and WOLFE, M.D.[2], [1]OSU - Ohio Sea Grant, 1314 Kinnear Rd., Area 100, Columbus, OH, 43212; [2]ODNR Division of Wildlife - District 3, 912 Portage Lakes Dr., Akron, OH, 44319.
Artificial Fish Habitat in Lake Erie Marinas.

Lake Erie marinas have the potential to provide exceptional spawning, nursery, and sport fish habitat. Most marinas already possess favorable characteristics such as calm, warmer water, and high productivity. One potential improvement that could be made is the addition of complex structure, which has been found to increase fish abundance in some lakes and reservoirs. This project - developed with input from marina and resource managers, fishermen, and boaters - evaluated the potential of artificial habitat structures to increase catch rates and improve localized fish populations in Ohio Lake Erie Marinas. Structures were placed in 7 marinas and monitored May-Sept using a combination of controlled angling, minnow traps, and stationary counts. Overall, the structures did not increase the number of fish or species in marinas. However, catch rates at both structure and control locations were high (mean 8.5 fish / hr). These results suggest the value of highlighting existing fishing opportunities. The addition of structure, if not innately beneficial, may help draw attention to this opportunity. These findings will be shared with marina and fisheries managers who will be able to make better informed decisions about enhancing fishing opportunities in marinas. *Keywords: Habitats, Fish, Lake Erie.*

WELSH, E., MINOR, E.C., and AUSTIN, J.A., Large Lakes Observatory 2205 East 5th Street, Duluth, MN, 55812. **The effect of photodegradation on dissolved organic matter (DOM) in Amity Creek.**

Photodegradation is known to affect dissolved organic matter (DOM) by altering its composition and reactivity, often making it more biologically active. In lentic systems, photodegradation is well documented and known to affect DOM; however, little is known about photodegradation in lotic systems. In this study, the potential for photodegradation in a lotic system was estimated using a dual dye approach to determine the light history of a parcel of water on its route downstream, and by performing in-lab irradiations of natural stream water. Initial findings show that maximum photobleaching of colored dissolved organic matter (CDOM) absorbance occurs when there is irradiation at wavelengths below 400 nm; long-wave pass filters at 345 and 360 nm exhibited photobleaching very similar to that seen for full-spectrum light, while there was distinctly less photodegradation with a 400 nm long-wave pass filter. The fluorescence ratio of fluorescein dye to rhodamine dye was found to respond to similar wavelengths, indicating that it should prove to be a useful in situ "actinometer" for photodegradation of CDOM occurring in a lotic system. *Keywords: Dissolved organic matter, Ultraviolet radiation, Carbon cycle.*

WESELOH, D.V.C.[1], MOORE, D.J.[2], and HEBERT, C.E.[3], [1]Canadian Wildlife Service, Environment Canada, 4905 Dufferin St., Toronto, ON, M3H 5T4; [2]Canadian Wildlife Service, Environment Canada, Box 5050, Burlington, ON, L7R 4A6; [3]National Wildlife Research Centre, Carleton University, Ottawa, ON, K1A 0H3. **Spatial and temporal patterns of contaminants in Herring Gull eggs from Lake Superior, 1974-2009.**

Contaminant levels in eggs of Herring Gulls (Larus argentatus) have been tracked annually at up to 15 sites on the Great Lakes since 1974. Two of those sites are in Lake Superior: Agawa Rocks, south of Wawa and Granite Island in Black Bay, near Thunder Bay. The objective of the study is to document spatial and temporal trends in contaminant levels in Herring Gull eggs. Thirteen eggs/site are collected in early May and analyzed for up to 75 different contaminants, including congeners. In 2009, contaminant concentrations at the Agawa and Granite sites, respectively, were (all units = ug/g, w.w. unless otherwise noted): Sum PCBs (1.43, 1.71), Sum BDEs (0.548, 0.411), Sum OCs (0.410, 0.461), Sum DDT (0.294, 0.359), HE (0.014, 0.011), HCB (0.013, 0.012) and TCDD (2.44 ng/g, 2.53 ng/g). Overall, eggs from Granite Island were slightly more contaminated than those from Agawa. Eggs from these Lake Superior colonies were the least contaminated of the sites sampled. Temporal trend analysis showed all contaminants had declined significantly since they were first sampled. Ecological tracers, i.e. stable isotopes and fatty acids, were used to evaluate dietary change in Lake Superior gulls and how that may influence contaminant trends. *Keywords: Lake Superior, Toxic substances, Bioindicators.*

WHITE, B.A.[1], MATSUMOTO, K.[1], and AUSTIN, J.A.[2], [1]University of Minnesota - Twin Cities, Minneapolis, MN, 55455; [2]University of Minnesota - Duluth, Duluth, MN, 55812. **Controls on Lower Trophic Level Ecosystem Trends in Lake Superior: A Numerical Modeling Study.**

Annual physical and biogeochemical dynamics in the North American Great Lakes are tightly coupled due to strong seasonal meteorological forcing. We use numerical modeling to study both physical and biological controls on lower trophic level ecosystem trends in Lake Superior. The Regional Ocean Modeling System (ROMS) a three-dimensional hydrodynamic model is used. A dynamic-thermodynamic ice model is coupled to the physical model. The coupled lower trophic level biological model is based on the nutrient-phytoplankton-zooplankton-detritus model described in Fasham et al. (1990) and modified to represent the strongly phosphorus limited state of Lake Superior. Examinations of both a persistent feature of the Lake Superior ecosystem, the deep chlorophyll maximum, and the role of ice cover in determining annual ecosystem dynamics are presented. *Keywords: Model studies, Ecosystem modeling, Lake Superior.*

WILEY, M.J., School of Natural Resources & Environment, University of Michigan, Ann Arbor, MI, 48109. **The simplification of complex river mouth channel systems: What do we know and what do we wish we knew?**

Decelerating flow velocities coupled with high sediment transport rates necessarily lead to complex channel development in the downstream terminus of alluvial systems. As a result river mouths around the world, are or are thought to have been, historically rich in anabranching and deltaic distributaries. Just as ubiquitous is the modern proclivity for anthropogenic channel simplification in service of transportation needs , flood control, and economic "expansion". In this paper I review some of what is known about channel system simplification in the GL basin and its likely ecological consequences. Since empirical data is scare simple theoretical models can provide a preliminary basis for anticipating ecosystem responses. Using the Muskegon and several other Michigan rivers as case studies I present a analysis of some potential implications of simplification for lower river and river mouth ecosystems. An obvious conclusion that emerges is that we need a more science focused on understanding what is lost along with complexity in valuable but troubled human-dominated river mouth systems.
Keywords: Hydrogeomorphology, Rivers, Ecosystems.

WILSON, G.B. and HEATH, R.T., Kent State University, P.O. Box 5190, Kent, OH, 44242. **Ecosystem-Based Management of the Lake Erie Ecosystem: A Survey-Based Approach to Assessment of Management Needs.**

A holistic, integrated management approach has been adopted in many large aquatic ecosystems. A survey-based approach was used to assess characteristics of implementation of the ecosystem approach (EA)/ecosystem-based management (EBM) in Lake Erie and four reference aquatic systems: Chesapeake Bay, Puget Sound, Tampa Bay and Baltic Sea with particular note on voluntary versus legislatively mandated implementation of EA/EBM parameters. To understand differences in perceptions of diverse stakeholders, survey respondents were stratified in two ways: by area of focus (Aquatic, Fisheries, Watershed and Ecosystem) and by type of organization (Government/Regulatory, Business/Industry, Academic and NGO). Correlations were analyzed for key parameters including EBM, positive outcomes, ecosystem size, condition and presence of a legislative mandate for all ecosystems collectively and Lake Erie particularly, including respondent stratifications. Contrasting perspectives on EBM implementation by various categories of stakeholders were shown. Ten principles for successful EBM implementation in large aquatic ecosystems are proposed, and the required attributes of a successful EBM model for large aquatic ecosystems are defined. A new EBM model for Lake Erie is recommended for effective protection and restoration of the ecosystem. *Keywords: Ecosystems, Ecosystem-based management, Lake management, Ecosystem management, Lake Erie, EBM.*

WINSLOW, C.J.[1], BUCKLEY, J.T.[1], and THOMAS, M.A.[2], [1]Biology Department, Kutztown University, Kutztown, PA, 19530; [2]878 Bayview Dr, The Ohio State University Stone Laboratory, Put-in-Bay, OH, 43456. **Hypoxia in the Western Basin of Lake Erie: Low oxygen in a shallow system.**

With an average depth of 7.3m, it is assumed that thermal stratification and hypoxia (dissolved oxygen ≤ 2.0 ppm) rarely occur in the Western Basin of Lake Erie. For this reason, little attention has been paid to the impact of hypoxia on the foraging and distribution of fish and zooplankton in the Western Basin. Yet on numerous occasions, we detected low dissolved oxygen and changes in fish distribution on calm summer days in this highly productive region of Lake Erie. In an attempt to assess the spatial and temporal occurrence of both temperature stratification and hypoxia, we deployed eight probes around the Bass Islands (7.4-9.0m) from June to September 2010. Four of eight submersed buoys contained sensors that recorded dissolved oxygen 10cm above the bottom, while all eight buoys measured temperature 0.5m above the bottom. Periods of stratification were recorded by each buoy. We observed a 2 degree (C) temperature stratification 31% of the time and a 6 degree (C) temperature stratification 5% of the time. Hypoxic conditions were recorded 19% and 68% of the time when the water column experienced a 2 or 6 degree temperature difference, respectively. Additionally, hypoxia occurred 12% of the time without temperature stratification. Across all buoys, hypoxia was present 17% of the time regardless of thermal stratification *Keywords: Fish, Hypoxia, Lake Erie.*

WITHERS, J.L., HOOK, T.O., TROY, C.D., and FOLEY, C.J., Purdue University, 195 Marsteller Road, West Lafayette, IN, 47907. **Larval yellow perch (*Perca flavescens*) and alewife (*Alosa pseudoharengus*) distributions in response to fine-scale temperature pattern in nearshore Lake Michigan.**

Yellow perch and alewife are ecologically and economically important species in Lake Michigan. Despite their significance, mechanisms controlling recruitment of both species remains elusive. Bottom-up effects such as prey availability and physical processes play an important role in determining early-life growth and survival of both species. We examined spatiotemporal distributions of larval yellow perch and alewife in nearshore Lake Michigan and quantified some of the biotic and abiotic factors influencing there distribution. We sampled larval fish, zooplankton, and measured temperature along a southern Lake Michigan transect on a biweekly basis during May-July 2010. Yellow perch began emerging in late May and persisted until mid-June while alewives began emerging in early June and persisted throughout July. Predatory zooplankton were present throughout the sampling period with greatest abundances occurring between mid-June and July. During the study time period we observed rapid changes in thermal conditions in nearshore Lake Michigan which seemingly influenced distribution of both larval fish and predatory zooplankton. Understanding how nearshore physical processes structure distribution and vital rates of important Great Lakes fish larvae should help explicate their recruitment dynamics and facilitate proactive management. *Keywords: Lake Michigan, Alewife, Temperature, Yellow perch.*

WOLTERING, M.L.[1], WERNE, J.P.[1], HICKS, R.E.[2], DAMSTE, J.S.S.[3], and SCHOUTEN, S.[3], [1]Large Lakes Observatory/ UMD, 2205E 5th st., Duluth, MN, 55812; [2]Department of Biology/ UMD, 10 University drive, Duluth, MN, 55812; [3]Department of Marine Organic Biogeochemistry, Royal Netherlands Institute for Sea Research, Den Burg (TEXEL), NH, 1791AB, the Netherlands. **Present day distribution of Crenarchaeota and their membrane lipids in large lake systems providing new insights into the interpretation of TEX86 temperature records from sediment archives of large lakes.**

The TEX86 paleotemperature proxy recently emerged as a quantitative biomarker proxy to reconstruct past lake temperature from sediment archives from large lake systems. This proxy is based on the relative degree of cyclization in the membrane lipids of archaea belonging to the lacustrine Group 1 Crenarchaeota. The TEX86 has been applied to sediment archives from large lakes like Lake Tanganyika and Malawi to produce long quantitative temperature records which were interpreted as mainly representing annual mean lake surface temperatures, although there is little information about the ecology of these archaea in lacustrine systems. Here we present the results of particulate organic matter study in Lake Superior and Malawi, where both biogeochemical and molecular biological analyses are combined to investigate the vertical ecology and lipid distribution of the Crenarchaeota in order to determine if or what kind of temperature is actually represented by this proxy in large lakes. Our results from Lake Superior and Malawi show that the nice of Crenarchaeota production is often located below the thermocline and thus the TEX86 partially reflects a subsurface water temperature and not an annual mean surface water temperature as was originally suggested. Interpretation of TEX86 temperature records should thus be adjusted accordingly. *Keywords: Paleolimnology, Sediments, Lake Superior.*

WOODRUFF, L.G.[1], WEAVER, T.L.[2], and CANNON, W.F.[3], [1]U.S. Geological Survey, 2280 Woodale Drive, Mounds View, MN, 55112; [2]U.S.Geological Survey, 6520 Mercantile Way, Lansing, MI, 48911; [3]U.S. Geological Survey, 12201 Sunrise Valley Drive, Reston, VA, 20192. **Environmental Baseline Study of the Huron River Watershed, Baraga and Marquette Counties, Michigan.**

In 2008, the U.S. Geological Survey (USGS) completed an investigation of water-quality parameters, and soil and streambed sediment geochemistry within the 83 square mile Huron River Watershed in the Upper Peninsula of Michigan. The area is semi-remote and sparsely populated, with extensive logging activity; regionally there is considerable interest in mineral exploration. Because of growing concerns over the ecological health of watersheds feeding into the Great Lakes, surveying and monitoring for future human-induced changes is critical. Effective monitoring requires a well-established baseline of current conditions. In the Huron River Watershed streamflow was periodically measured and water-quality samples collected at a range of flow conditions from 6 sites on the major tributaries. Water samples were analyzed for a suite of common

ions, nutrients, trace metals, and unfiltered total and methylmercury. Soil samples were collected from 31 sites, with separate samples collected at each site delineated by soil horizon. Streambed sediments were collected from 11 sites selected to cover most of the area drained by the river system. Results from this study define the ambient background hydrological and geochemical conditions for the Huron River Watershed prior to any potential mineral exploration or development. *Keywords: Water quality, Geochemistry, Regional analysis, Soils, Watersheds, Baseline.*

WRUBLESKI, D.A.[1], KROEKER, D.S.[2], and WATKINSON, D.A.[3], [1]Ducks Unlimited Canada, P.O. Box 1160, Stonewall, MB, R0C 2Z0; [2]Fisheries Branch, Manitoba Water Stewardship, Box 6000, Gimli, MB, R0C 1B0; [3]Fisheries and Oceans Canada, 501 University Crescent, Winnipeg, MB, R3T 2N6. **Restoration of Delta Marsh, Manitoba: Exclusion of Common Carp.**

Delta Marsh is a large freshwater coastal wetland on the south shore of Lake Manitoba. Similar to other freshwater habitats, it is suffering from the effects of an artificially modified hydrology, eutrophication and invasive species. One of the invasive species of concern is Common Carp (*Cyprinus carpio*). Field observations and experimental studies have implicated Common Carp in several changes observed in the marsh. A restoration plan is currently being developed for the marsh and minimizing Common Carp impacts is considered an important part of the plan. Each fall, all large fish leave the marsh as it begins to freeze. Bar screens placed on the connecting channels would be able to exclude Common Carp when they return each spring. However, screens would exclude native species such as Walleye, Northern Pike and White Sucker. To minimize screen impacts on these species several research studies are currently underway to determine optimum screen opening size and timing of screen placement. Fish passage through experimental screens of different size is being evaluated. In addition, the timing of fish movement into the marsh and the size structure of the large fish community is being determined. *Keywords: Carp, Invasive species, Coastal wetlands.*

XIA, X.[1], HOPKE, P.K.[2], HOLSEN, T.M.[3], CRIMMINS, B.S.[1], PAGANO, J.J.[4], and MILLIGAN, M.S.[5], [1]Center for Air Resource Engineering and Science, Clarkson University, Potsdam; [2]Department of Chemical & Biomolecular Engineering, Clarkson University, Potsdam; [3]Department of Civil & Environmental Engineering, Clarkson University, Potsdam; [4]Environmental Research Center, State University of New York at Oswego, Oswego; [5]Department of chemistry and biochemistry, State University of New York at Fredonia, Fredonia. **Toxaphene concentrations and trends in the Great Lakes top predator fish.**

Toxaphene was one of the most heavily used insecticides in the United States until most uses were banned in 1982. It is a complex mixture of more than 670 chlorinated camphene derivatives. Toxaphene is one of the major environmental contaminants of concern in the Great Lakes. As part of the U.S. Great Lakes Fish Monitoring and Surveillance Program, more than 300 lake trout and walleye from the

Laurentian Great Lakes collected from 2004 to 2009 were analyzed for toxaphene. The toxaphene concentrations in fish samples show that LS lake trout has the highest concentration and LE walleye has the lowest concentration. In general, concentrations have decreased over time although recent concentrations have been more constant than historical values. In an effort to better understand the variation in toxaphene concentrations in Great Lakes fish, the coastal zone model for persistent organic pollutants was used to simulate toxaphene behavior in the Great Lakes. The performance of the model was evaluated by comparing calculated and measured concentrations in Great Lake top predator fish. Simulated and observed concentrations agree within one order of magnitude with a general pattern of rapid decline since their peak around 1980's, followed by a more gradual decrease. *Keywords: Chemical analysis, Environmental contaminants, Fish.*

YANG, R., WEI, H., and LI, A., University of Illinois at Chicago, 2121 W. Taylor St., Chicago, IL, 60612, United States. **Non-PBDE Flame Retardants in the Sediment of the Great Lakes.**

About 70% of the >600 organic substances prioritized for environmental monitoring in North America are halogenated. Among them, brominated flame retardants (BFRs) are a group of chemicals with diverse structures and physicochemical properties. Many "emerging" BFRs have not been monitored, little information on their environmental occurrences is available. In this work, 16 sediment cores were collected in the five Great Lakes, and the concentrations of 13 non-PBDE BFRs were analyzed using GC/MS. Among them, 1,2-dibromo-4-(1,2-dibromoethyl)cyclohexane (TBECH), 1,2-bis-(2,4,6-tribromophenoxy)ethane (BTBPE), hexachlorocyclopentadienyl-dibromocyclooctane (HCDBCO), hexanbromocyclododecane (HBCD) and decabromodiphenylethane (DBDPE) were the most frequently detected, especially in recently deposited sediment segments. These BFRs were found to have much lower total accumulation in the Great Lakes sediments than those previously reported for decabromobiphenyl ether (BDE209), Dechlorane (mirex), Dechlorane Plus (DP), and Dechlorane 602. In addition, their spatial distribution pattern appears to distinctly differ from those of Dechlorane related flame retardants, indicated by the much weaker correlations with the latitude and longitude of the sampling locations. The time trends of input were also examined. *Keywords: Environmental contaminants, Emerging pollutants, Sediments, Brominated flame retardants, PBDEs.*

YOUSEF, F.[1], KERFOOT, W.C.[1], SHUCHMAN, R.A.[2], GREEN, S.A.[1], and SABOL, B.M.[3], [1]1400 townsend DR, Michigan Technological University, Houghton, MI, 49931; [2]3600 Green Ct., Ste. 100, Ann Arbor, MI, 48105; [3]3909 Halls Ferry Road, Vicksburg, MS, 39180-6199. **LiDAR (Light Detection and Ranging) And MSS (Multi-spectral Scanner) Studies Of Lake Superior Coastal Environments.**

Due to its high spatial resolution, the combined use of coastal LiDAR (Light Detection and Ranging) and MSS (multi-spectral scanner) imagery has great potential for environmental restoration studies. On June 2008, using the Compact Hydrographic Airborne Rapid Total Survey (CHARTS) system, a USACE-ERDC mission collected LiDAR and multi-spectral scanner CASI (Compact Airborne Spectrographic Imagery) scans over Big Traverse Bay, southern shoreline of Lake Superior. Penetrating down to a water depth of 22m, LiDAR scans produced detailed elevation and bathymetric maps along the coastal margin. Applying a combination of historic aerial photography and LiDAR, we estimated the time course and amount (19.5 Mt) of stamp sands eroding from the original Gay tailings pile into Keweenaw Bay. Aided by differences in spectral reflectance between bottom substrates and use of Satlantic water column spectral profiles, we also constructed MSS-based classifications of underwater substrates. The studies revealed an urgent underwater threat to Buffalo Reef, a primary lake trout and whitefish breeding ground. *Keywords: Lake Superior, GIS, Remote sensing.*

YUCUIS, R.A. and HORNBUCKLE, K.C., 4105 Seaman's Center, University of Iowa, Iowa City, IA, 52242. **Organosiloxane Compounds in the Great Lakes: Preliminary Method Development and Results.**

The organosilicon compounds octamethylcyclotetrasiloxane (D4), decamethylcyclopentasiloxane (D5), and dododecamethyl-cyclohexasiloxane (D6) are widely used in household goods and personal care products and have been targeted for study as possible POPs. The purpose of this work is to develop a method for the sampling and analysis of three cyclic siloxane compounds in air with the ultimate goal of researching the emissions and transport of siloxanes in the Chicago area. Here we report the preliminary instrumental method for electronic impact mass detection and gas chromatography. A linearity study for D4, D5, D6, and the internal standard tetrakis(trimethyl-siloxysilane) (M4Q) was completed. The reliability of the internal standard was examined, and a study of the sample carry-over and internal contamination in the instrument was carried out. We also report our preliminary sampling and extraction method. Sampling was conducted by drawing air through SPE cartridges with a diaphragm pump. The cartridges were then extracted directly into GC vials. Overnight samples were taken in the labs, student office, and instrumental room to get background concentrations. Lastly, three samples taken near Navy Pier in September of 2010 were analyzed to establish a preliminary concentration range for siloxanes in the Chicago environment. *Keywords: Environmental contaminants, Lake Michigan, Pollutants.*

YURISTA, P.M., KELLY, J.R., MILLER, S.E., and VANALSTINE, J.D., US EPA MidContinent Ecology Division, 6201 Congdon Blvd., Duluth, MN, 55804. **Lake Michigan Green Bay: nearshore variability.**

We conducted a high-resolution survey in the nearshore of Lake Michigan's Green Bay at a 15 meter contour using towed electronic instrumentation. The 365 km survey was conducted Aug 18-21, 2010. We also conducted four cross-contour tows. Along the survey tracks we sampled fixed stations (7) to collect calibration data and other parameters not observed by the in situ electronic sensors. With the towed sensor data we constructed a comprehensive representation of spatial variability in the nearshore. We analyzed for potential signals within the variability that may be correlated to landscape characteristics of the adjacent coastal watersheds using multivariate stepwise regressions. The correlation to landscape character explained a large amount of the variation in specific conductivity, beam attenuation, fluorescence, and NO3 (r2; 0.84, 0.78, 0.74, and 0.40 respectively). The survey provided an overview of variability in the nearshore of Green Bay Lake Michigan. This abstract does not necessarily reflect USEPA policy. *Keywords: Lake Michigan.*

ZANATTA, D.T. and ROWE, M.T., Central Michigan University, Biology Department, Brooks Hall, Mount Pleasant, MI, 48859. **Twenty-five Years of Change in the Bivalve Communities of Lake St. Clair.**

Lake St. Clair was among the first bodies of water in North America to be invaded by *Dreissena* in the mid-1980s. The impacts of *D. polymorpha* on the lake's native freshwater mussel communities (Unionidae) were massive with unionid densities dropping below detectable levels and species diversity declining to zero by the mid-1990s. Extirpation was assumed. However, in the late 1990s, low-density unionid communities were rediscovered in the shallow bays of the St. Clair delta. Between 1999 and 2003, 22 species were found alive including several species of conservation concern. Renewed monitoring in 2010 at sites on the Michigan side of the delta revealed that the ecosystem remains in flux. Rates of *Dreissena* infestation on unionid shells decreased significantly between 2003 and 2010 (P<0.05) at all sites. Unionid densities are also changing, with some sites showing marked decreases, some showing stability, and others showing significant (P<0.05) increases. The reasons for these changes in the bivalve communities in the St. Clair delta are still being investigated. New research is now beginning on the genetic population structure and source-sink dynamics of unionids in the St. Clair delta refuge and surrounding tributary streams, giving insight for conservation prioritization. *Keywords: Unionids, Refuge, Dreissena, St. Clair delta, Lake St. Clair.*

ZHANG, H.[1], RUTHERFORD, E.S.[2], and MASON, D.M.[2], [1]Cooperative Institute for Limnology and Ecosystems Research, University of Michigan, Ann Arbor, MI, 48108; [2]NOAA-Great Lakes Environmental Research Lab., 4840 s. State Rd., Ann Arbor, MI, 48108. **Potential impacts of Asian carps on the food web and fisheries in a Lake Michigan estuary.**

Bighead (*Hypophthalmichthys nobilis*) and silver (*H. molitrix*) carp (Asian carps) threaten to invade the Great Lakes and disrupt aquatic food webs and fisheries. Muskegon Lake (ML) is a shallow, productive, drowned river mouth lake that supports important recreational fisheries and provides nursery habitats for many ecologically or economically important fishes of Lake Michigan. ML is susceptible to Asian carp invasion given its eutrophic status, its close proximity to the sources of Asian carps, and the presence of suitable spawning habitat upstream in the Muskegon River. We used

EcoPath with EcoSim (EwE) to evaluate the potential impacts of Asian carps on food web structure, fish production and fisheries. The food web model included 1 detritus group, 1 algal group, 5 zooplankton groups, 15 fish groups with a couple of species broken down to 2-3 life stages, and 5 benthic groups. We used data collected from ML during 2000-2006 to balance the EcoPath model. Under current conditions of nutrient loading, fish stocking and harvest, we added Asian carps to the food web, and used EcoSim to forecast the potential impacts of Asian carps on food web structure and fish production over a period of 50 years. *Keywords: EcoPath/EcoSim, Food web model, Asian Carps.*

ZHANG, X.[1], RYGWELSKI, K.R.[2], ROWE, M.D.[2], ROSSMANN, R.[3], and KREIS, R.G.[2], [1]ICF International, 9311 Groh Rd, Grosse Ile, MI, 48138; [2]USEPA/ORD/NHEERL/MED/, Large Lake Research Station, 9311 Groh Rd, Grosse Ile, MI, 48138; [3]Visiting Scientist, Groh Rd, Grosse Ile, MI, 48138. **Global and Local Contributions to Mercury Concentrations in Lake Michigan and Impact on Fish Consumption Advisories.**

LM2-Mercury, a mercury species mass balance model developed for Lake Michigan, was used to assess mercury cycling in Lake Michigan. A calibrated model (including a hindcast) was used to predict mercury concentrations in the lake based on various loading, air concentrations, sensitivity and management scenarios. The model results indicate that atmospheric components including wet, dry deposition, and Hg absorption are very important in controlling the mercury concentration in the lake. Based on two very different global background scenarios, the model was used to investigate the relative importance of global vs regional impacts to mercury concentrations in Lake Michigan. The model results for the global background scenario constructed, based on information from the current literature, indicate that the global contribution could be the foremost controlling factor of the Hg concentration level in the lake. Model forecasts of total mercury concentrations in the water will be compared to EPA 2001 fish consumption criteria. Though post-audit data are few, model predictions appear to comparable to measured mercury concentrations. This abstract does not necessarily reflect USEPA policy. *Keywords: Ecosystem forecasting, LM2-Mercury, Mercury, Lake Michigan.*

ZHU, X., JOHNSON, N.W., and BECK, B., 105 Swenson Civil Engineering, 1405 University Drive, Duluth, MN, 55812. **Protecting the St. Louis Estuary by reducing Polycyclic Aromatic Hydrocarbons (PAHs) levels in stormwater runoff.**

Polycyclic Aromatic Hydrocarbons (PAHs) are one of the most important, abundant, and dangerous classes of persistent organic contaminants found in air, water, food and waste sites. PAHs accumulate in the tissue of organisms, jeopardizing their health and leading to unsafe human exposure . Recent studies have revealed the emerging problem of PAH-laden sediment in stormwater ponds around Minnesota as well as other states in the US. The outfall from malfunctioning stormwater ponds laded with unknown

PAH content draining to St. Louis Estuary exhibits a threat to the health of this sensitive Great Lakes Ecosystems. It is our purpose to present the concerns of the potential/on-going deleterious effects of PAH-laden stormwater discharging to Lake Superior and our proposed efforts to alleviate the impact on its aquatic ecosystem. Potential endeavors include PAHs sources identification to facilitate efficient source control and investigation of PAH level in stormwater pond sediment to support cost-effective management strategies for dredged pond materials. *Keywords: PAHs, Lake Superior, Ecosystem health.*

ZHU, X.[1], DAY, A.C.[1], TAPTUNA, F.[2], CARMICHAEL, T.J.[1], and TALLMAN, R.F.[1], [1]Freshwater Institute, Fisheries and Oceans Canada, 501 University Crescent, Winnipeg, MB, R3T 2N6, Canada; [2]Fisheries and Oceans Canada Hay River Office, 42043 MacKenzie Highway, Hay River, NT, X0E 0R9, Canada. **Modeling time-varying growth pattern of Lake Whitefish (*Coregonus clupeaformis*) using hierarchical Bayesian growth models.**

Lake Whitefish commercial fishery on Great Slave Lake, Northwest Territories, Canada, has been operating since 1945, and undergone a dramatic decline from 2605 tonnes in 1949-50 to 297 tonnes in 2008-09. Yearly variation in growth has been identified, never incorporated into growth models. Our current study explored hierarchical Bayesian models to examine temporal variations in growth patterns over six administrative areas during 1972-2004. Of four candidate models, the best hierarchical Bayesian growth model was incorporated with time-varying both asymptotic fork length (L_∞) and the Brody growth coefficient (K). The posterior hyper-parameters L_∞ and K displayed clear spatiotemporal variations, ranging from 459.2 to 603.2 mm and 0.1161 to 0.2756, respectively. Spatially, smaller L_∞ and larger K values appeared in deep-water areas (areas IV and V), while larger L_∞ and smaller K values were found in the shallow southern waters (areas IW, IE, and III). The cause-effects shifting biological traits in Whitefish are diverse, ascribed to altering population status, condition index, and hydroclimate variables. The use of a Bayesian hierarchical approach is generally suggested for further age-structured models and population reduction models that include growth when making precautionary management decisions. *Keywords: Great Slave Lake, Fish populations, Bayesian, Model studies, Growth, Climate change.*

ZIGAH, P.K.[1], REPETA, D.[2], MINOR, E.C.[3], MCNICHOL, A.[4], and XU, L.[4], [1]Large Lakes Observatory and Water Resources Science Program, University of Minnesota Duluth, Duluth, MN, 55812; [2]Department of Marine Chemistry and Geochemistry,, Woods Hole Oceanographic Institution, Woods Hole, MA, 02543; [3]Large Lakes Observatory and Dept. of Chemistry and Biochem., University of Minnesota Duluth, Duluth, MN, 55812; [4]National Ocean Sciences Accelerator Mass Spectrometry Facility, Woods Hole Oceanographic Institution, Woods Hole, MA, 02543. **Δ14C of Biochemical Compound Classes in High Molecular Weight Dissolved Organic Carbon Isolated from Lake Superior.**

Dissolved organic carbon (DOC) in the water column of aquatic systems contains a variety of biochemical compounds (such as carbohydrates, proteins, lipids, and nucleic acids) that reflect multiple sources, and different pathways of synthesis and diagenetic alteration. The radiocarbon ($\Delta^{14}C$) signatures of compound classes are important in teasing apart the spectrum of ^{14}C distribution within the DOC, and allow for a more robust and accurate interpretation of the various sources and biogeochemical sinks of organic carbon in aquatic systems. In this study, we analyzed the $\Delta^{14}C$ content of compound classes isolated from high molecular weight dissolved organic carbon (HMW DOC, >1 kDa) in Lake Superior. The $\Delta^{14}C$ values indicate that total hydrolysable amino acids (THAA) and total hydrolysable carbohydrates (TCHO) were younger (^{14}C-enriched), recycled rapidly, and were mostly derived from recent in situ primary production (also confirmed by the $\delta^{13}C$ values) in the lake. The solvent extractable lipids (TLE) in contrast, were considerably older (^{14}C-depleted), indicating recycling over long time scales, and most likely came from sedimentary sources or considerably aged terrigenous organic carbon. *Keywords: Biogeochemistry, Radiocarbon, Carbon cycle, Lake Superior.*

ZIGLER, O.[1], AUSTIN, J.A.[2], and VINSON, M.R.[3], [1]UM Duluth, Duluth, MN, 55812; [2]Large Lakes Observatory, UM Duluth, Duluth, MN, 55812; [3]USGS Lake Superior Biological Station, 2800 Lakeshore Drive East, Ashland, WI, 54806. **Development of a historical water temperature profile data base for Lake Superior.**

The United States Geological Survey Lake Superior Biological Station has collected a variety of data on Lake Superior over the last several decades. Between 1958 and 1971, thousands of temperature profiles were collected with a bathythermograph, which mechanically records temperature profile data onto a gold coated glass slide which is then photographed and archived. We have developed a method of efficiently digitizing these records so that the data can be used to diagnose the state of Lake Superior thermal structure prior to the era of modern measurements. We have processed several hundred of the slides into a database so far and anticipate that we have roughly 1000 more slides to process, which will result in a database of temperatures in waters up to 150m deep from 1958-1971. This will be a valuable resource to researchers trying to characterize and quantify the impact of long-term climate change on the lake. *Keywords: Climatic data, Thermal structure, Lake Superior.*

ZORN, T.G. and SCHNEEBERGER, P.J., Michigan DNR, Marquette Fisheries Research Station, 484 Cherry Creek Road, Marquette, MI, 49855. **Walleye movement and sport fishery responses to habitat changes in Little Bay de Noc, Lake Michigan since 1988.**

The Michigan waters of Green Bay support the largest recreational fishery in Michigan's Upper Peninsula, with walleye being a primary target. Little Bay de Noc (LBDN), a focal area of the fishery, has been intensely managed for walleyes (stocking and special regulations), and influenced by numerous invasive species, most notably dreissenid mussels. Since 1988, the LBDN fish community has been monitored with gill

net and trawl surveys, and jaw-tagging has been used to assess walleye movement and exploitation. By 2005, summer water clarity had increased 45% in LBDN, and August and September surface water temperatures climbed 16%. Assessment survey data for the period showed declines in pelagic forage fishes (trout-perch, rainbow smelt, spottail shiner, and alewife). In addition, as our study progressed, walleyes tagged at the northern end of LBDN and later recaptured in spring and summer were generally caught further and further from the tagging site. The proportional contribution of summer-caught walleyes to the LBDN fishery also declined substantially. Both observations meshed with angler comments, suggesting a shift in the fishery in response to changing biophysical conditions in LBDN. Our findings are somewhat unique in documenting the redistribution of walleyes and sport fishery responses to water clarity changes.
Keywords: Walleye, Green Bay, Fish populations, Spatial distribution, Dreissena, Lake Michigan.