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Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

ACKERMAN, J.D. and LI, J., Faculty of Environmental Sciences, University of Guelph, Guelph, ON, N1G 3A7. **A Review of Graduate Programs in the “Environmental Sector” in Canada.**

This review of graduate programs in the environmental sector was undertaken to examine the distribution and characteristics of training in Canada. Three categories of Environmental Graduate Programs were distinguished: (1) Environmental Science programs, which are science based and integrate natural, physical and social sciences; (2) Environmental Studies Programs, which are humanities based; and (3) Discipline-based programs, which examine environmental issues within a single disciplinary perspective. Currently, there are ~63 Masters and ~27 PhD programs in the environmental sector in Canada. Only 13 of these programs (9 Masters and 4 PhD programs) are defined as Environmental Science. The Province of Ontario offers about half the graduate programs in the environmental sector, although only 4 Masters and 3 PhD programs can be classified as Environmental Science. Given this data set, the fact that there has been continued growth in the environmental employment sector, and the needs for significant increases in training as identified by governments, it is evident that more graduate training programs in Environmental Science are needed. Graduates of such programs should possess the integrative and interdisciplinary skills needed to understand how environments function and how to deal with environmental perturbations. *Keywords: Education.*

ADAMS, J.M.¹, HINCHEY MALLOY, E.K.¹, HORVATIN, P.J.², WARREN, G.J.², and MAY, J.C.³, ¹77 W. Jackson Blvd, G-17J, Chicago, IL, 60604; ²77 W. Jackson Blvd, G-17J, Chicago, IL, 60604; ³77 W. Jackson Blvd, G-17J, Chicago, IL, 60604. **U.S. EPA Great Lakes National Program Office Nearshore Monitoring using the TRIAXUS Towed Instrument Platform.**

Nearshore monitoring is an important factor in assessing the ecosystem health of the Great Lakes, but it often presents a challenge due to the limited availability of research vessels and difficulty in surveying the extensive (>10,000 miles) shoreline. The U.S. EPA Great Lakes National Program Office (GLNPO) deploys a TRIAXUS 3D towed undulating vehicle from the R/V Lake Guardian in all five Great Lakes in waters as shallow as 20m to gain more insight into nearshore water quality and habitat characteristics. This state of the art towed instrument platform provides real-time multiparameter profile data of the nearshore water column over a large shoreline distance as well as supplements the GLNPO open water surveys. Details of the TRIAXUS specifications, the various sensors it houses, sampling locations, and preliminary results will be presented. *Keywords: Monitoring, Nearshore, Habitats, Water quality.*

ADLERSTEIN, S.A., GRAMLEY, J., CHAMBERS, E., HESEL TINE, D., MERSEREAU, J., TAYLOR, K., VEDEJS, C., and VOGEL, J., University of Michigan, Ann Arbor, MI, 48109, US. **Mapping the Huron River.**

Mapping the Huron River is a video recording from a multimedia performance done as collaboration among artists and scientists on the cycle of water and the relationship of water and culture. The project was implemented as part of Art on Earth, a program intended to bring together science and art across University of Michigan academic units. During 2008 the program

was oriented to Arts and the Environment and promoted projects around the four elements as themes. “Mapping the Huron River” was conceived by the water group as an environmental education outreach piece. The performance includes videography, poetry, dance, acting, music, photography and painting within a scientific context. It takes the audience into an immersive experience: from rain replenishing the ground water at the Huron River headwaters to downstream towards Lake Erie, the Atlantic Ocean and back into rain. The piece describes the river journey from pristine to less desirable conditions as water flows through urban areas through images, sound and spoken words. A start celebrating nature ends on a dark note on the extermination of native freshwater mussels in segments of the rivers within the University of Michigan campus, and cautions about the consequences of unsustainable environmental practices. *Keywords: Public education, Ecosystem health, Outreach.*

ADLERSTEIN, S.A.², SILVERMAN, E.¹, and SLADE, J.¹, ¹440 Church Street, Ann Arbor, MI, 48109; ²11510 American Holly Dr, Laurel, MD, 20708-4002; ³229 S. Jebavy, Ludington, MI, 49431. **Distribution of Sea Lamprey Larvae in Lower Michigan Peninsula Tributaries Based on Habitat.**

We developed models by stream and basin to understand distributions of sea lamprey larvae in 29 Michigan and 20 Huron tributaries. We used modern regression to model densities of young-of-the-year, age one and older larvae from 1999 to 2004 Quantitative Larval Assessment (QAS) and explanatory variables measured during QAS and taken from other databases or derived from models. About half of the stream-specific models explained more than 50% of the density variation; with best predictions for Michigan tributaries. Basin models explained 24 to 47%. Best predictors, accounting for years since lampricide treatment, were habitat type, valley segment hydrology, and distances to upstream spawning habitat and to the river mouth. Overall, densities were double in preferred than acceptable habitat and higher in groundwater than in runoff stream segments, were higher close to spawning habitat and varied with distance to the river mouth depending on the stream and larval size and decreased with depth. Our models help to understand larval distributions in Michigan and Huron tributaries where no QAS have been conducted, such as above impermeable dams. Since data available came from streams with high larval densities and often treated with lampricide, random samples are necessary for refining the analysis. *Keywords: Spatial distribution, Invasive species, Management.*

AGUILAR, C.¹, CUHEL, R.L.¹, and HENSGEN, J.², ¹UW-M WATER Institute, 600 E. Greenfield Ave., Milwaukee, WI, 53204, USA; ²Fox River Middle School, 921 West Main Street, Waterford, WI, 53185, USA. **From Hands In to Hands On: Transfer of Shipboard Research Experience to the Classroom.**

This experience for teachers provides a model study with issues current to the Great Lakes Basin for educators to participate in data acquisition, measurements, and analyses. Through hypothesis testing research experience, we provide an educator component that runs simultaneously with research cruises on how to design and integrate outdoor field work and Great Lakes issues into the school curriculum. Hands-on demonstrations provide an important

link between sampling on the UWM R/V Neeskay coupled with laboratory work. Interaction between Scientists and educators provides a platform to encourage critical thinking, translating the concepts learned into personal experiences and making science relevant to everyday life. Scientists and educators work together to customize and scale classroom learning experiences to be integrated with authentic research cruises on Lake Michigan providing experiential learning. The tools used are bucket to ROV on the other end of technology. Educator familiarity with methods, analysis and results, and dissemination of environmental research must be elevated to a significantly higher level than it is today. This is necessary to develop generations of students with knowledge of local and global environments for which they may ultimately help make policy decisions through elections and referenda. *Keywords: Education, Dreissena, Shipwrecks.*

AHERN, R.G.¹, LANDIS, D.L.¹, REZNICEK, A.A.², and SCHEMSKE, D.W.³, ¹Michigan State University, Department of Entomology, East Lansing, MI; ²University of Michigan Herbarium, Ann Arbor, MI; ³Michigan State University, Department of Plant Biology, East Lansing, MI.

Spread of Exotic Plants in the Landscape: the Role of Time, Biological Traits, and History of Invasiveness.

We investigate the significance of residence time, biological traits, and history of invasiveness on the spread of exotic plants in Michigan and California. Minimum residence time was significantly associated with number of counties invaded, explaining 39% to 44% of variation in rates of landscape spread. In contrast, species traits and history of invasiveness explained a small but significant fraction of variation in spread in California but not Michigan. In both states we found significant positive correlations between minimum residence time and species occurrence on state invasive plant lists. Given recent high rates of establishment (≥ 50 species per decade) and evidence that many species will become invasive over time, there is an urgent need to develop effective policies for exotic plant management. We conclude that efforts to selectively exclude species based on biological characteristics will have limited success, and instead endorse active exclusion coupled with rapid detection and early response.

Keywords: Biological invasions, Exotic species, Policy making.

AHMED, S. and TROY, C.D., 550 Stadium Mall Drive, West Lafayette, IN, 47907-2051, United States. **Hydrodynamic Simulations of Stratified Flow in Lake Michigan Using SUNTANS.**

Hydrodynamic simulations of wind-driven, stratified flow in Lake Michigan are performed using the model SUNTANS. This model (Stanford Unstructured Nonhydrostatic Terrain-following Adaptive Navier-Stokes Solver) has been applied with good success to the simulation of internal waves in coastal environments, and has potential to provide high-resolution, accurate predictions of circulation in the Great Lakes. It is applied here to the simulation of coastal upwellings and internal Kelvin waves in Lake Michigan. The Lake Michigan upwelling test case presented by Beletsky et al. (1997) is used for model validation, and model results compare favorably to these simulations. Related modeling and measurement efforts involving Lake Michigan are also discussed. *Keywords: Lake Michigan, Hydrodynamics, Coastal processes.*

ALEXANDER, J.F., Michigan State University Press, 1405 S. Harrison Road, East Lansing, MI, 48823-5245. **Preventing Invasions with Public Policy.**

Completion of the Great Lakes-St. Lawrence Seaway 50 years ago linked ports on all five of the Laurentian Great Lakes to the global shipping trade. The Seaway increased international trade in the Great Lakes region but there were tradeoffs, mostly due to transoceanic freighters inadvertently importing aquatic invasive species via ballast water discharges. In this session, I examine the role of public policy in preventing transoceanic vessels from importing invasive species into the lakes during the Seaway's first 50 years. I will discuss efforts by government agencies in the U.S. and Canada to address this problem and missed opportunities to slow the rate of aquatic invasive species entering the lakes via the ballast water vector. Finally, I will explain why the number of shipborne aquatic invasive species discovered in the Great Lakes increased after the U.S. and Canada passed laws designed to stem the tide of invaders.

Keywords: Invasive species, Ballast, Policy making.

ALI, A.K., WITTER, D.L., and ORTIZ, J.D., Department of Geology, Kent State University, Kent, OH, 44242. **Multivariate Assessment of Remotely Derived Water Quality Parameters in the Western Basin of Lake Erie.**

The application of a multivariate statistical approach to interpretation of optically complex Landsat images of Lake Erie obtained from March-August 2003 is presented. Although there has been considerable effort to use remotely sensed images to provide spatial information for water quality parameters in open water environments, limitations in the understanding of optical characteristics of "case 2" waters present challenges for identification and assessment of environmental stressors such as high concentrations of chlorophyll *a*, macro algae, colored dissolved organic matter (CDOM) and suspended sediments (SS). Proper orthogonal decomposition (POD) of high-resolution multispectral data from the western basin results in three orthogonally defined spectral signatures (CDOM/water, chlorophyll *a*, and SS) accounting for 94.7% of the total spatial variability. Significant temporal changes in the distribution of CDOM and SS in the western basin can be tracked from POD applied to sequences of images. Effects of clouds and haze are extracted as higher-order components. This study demonstrates that advanced multivariate techniques may be employed to identify and assess water quality parameters in optically complex environments. This will increase the efficiency and accuracy of monitoring and mapping pollution dynamics. *Keywords: Remote sensing, Water quality, Lake Erie.*

ANDERSON, E.J., SCHWAB, D.J., and LANG, G.A., NOAA - Great Lakes Environmental Research Lab, 4840 South State Rd., MI, 48108, US. **3D Hydrodynamic and Hydraulic Modeling of the Huron-Erie Corridor: Operational Forecasting System and Current Comparisons.**

A three-dimensional unstructured hydrodynamic model of the Huron-Erie Corridor (St. Clair River, Lake St. Clair, and the Detroit River) has been developed to provide operational

nowcasts and forecasts of physical conditions and scenario testing for contaminant tracking in the system. Nowcasts are performed eight times per day and 48-hour forecasts are performed two times per day. Comparisons between model simulations and observed values show average differences of 3 cm for water levels and 12 cm/s for along-channel currents in the St. Clair River (compared to mean current values of 1.7 m/s). In addition, hindcasts of conditions using 1985 meteorology are compared with current observations at twelve mooring stations in Lake St. Clair. In general, the uncertainty in computed currents in the lake is much greater than in the rivers simply because of the associated uncertainty in boundary conditions. In the western and central regions of the lake, currents compare well with observations in both mean and time-variable flow (normalized Fourier norms range between 0.18 and 0.75). Currents in the eastern part of the lake are an order of magnitude smaller and yield higher uncertainty between computed and observed values (normalized Fourier norms range between 0.83 and 1.13).
Keywords: Lake St. Clair, Hydrodynamic model, St. Clair River.

ANGEL, J.R.¹ and KUNKEL, K.E.², ¹Illinois State Water Survey, 2204 Griffith Drive, Champaign, IL, 61821, USA; ²Desert Research Institute, 2215 Raggio Parkway, Reno, NV, 89512, USA. **The Response of Great Lakes Water Levels to Future Climate Scenarios with an Emphasis on Lake Michigan.**

Future climate change and its impact on the Great Lakes is an important issue for water supply planning. To estimate possible future levels of the Great Lakes due to climate change, the output of 565 model runs from 23 Global Climate Models were applied to a lake-level model developed by the Great Lakes Environmental Research Laboratory (GLERL). In this study, three future emission scenarios were considered: the B1, A1B, and A2 emission scenarios representing relatively low, moderate, and high emissions respectively. The results showed that the A2 emission scenario yielded the largest changes in lake levels of the three emission scenarios. Of the three periods examined, lake levels in 2080-2094 exhibited the largest changes. The response of Lake Superior was the smallest of the Great Lakes, while Lakes Michigan-Huron, Erie, and Ontario were similar in their response over time and between emission scenarios. However, the range in lake levels was considerable. The wide range of results is due to the differences in emission scenarios and the uncertainty in the model simulations. Selecting model simulations based on their historical performance does little to reduce the uncertainty. The wide range of lake level changes found here make it difficult to envision the level of impacts that change in future lake levels would cause. *Keywords: Climate change, Water level, Great Lakes basin.*

ARBOGAST, A.F.¹, MONAGHAN, G.W.², LOVIS, W.A.³, and FORMAN, S.L.⁴, ¹Michigan State University, Department of Geography, East Lansing, MI, 48824; ²Glenn Black Laboratory, Indiana University, Bloomington, IN, 47408; ³Michigan State University, Department of Anthropology, East Lansing, MI, 48824; ⁴Department of Earth and Environmental Sciences, University of Illinois at Chicago, Chicago, IL, 60607-7059. **Lake Michigan Coastal Dunes are Complex: Two Models for Their Formation in the Northeastern Part of the Basin.**

Recent research has focused on the formation of coastal dunes in the northern Lake Michigan basin. In contrast to dunes along the southeastern shore, most northern dune fields are

associated with embayments. Dunescapes in these environments typically contain several ridges, with the largest (~ 30-m high) usually the most inland. Systematic OSL dating indicates that Nipissing dunes are rare and that the largest ridges formed ~ 3.3 ka. Subsequent pulses of dune formation occurred at ~ 2.1, 0.9, and from 0.5-0.3 ka. These results may have significant implications regarding eolian sand supply and lake level fluctuations. It appears that eolian sand supply was highest during the post-Nipissing lake regression, suggesting a temporal lag between coastal erosion of sand and its ultimate deposition in dunes. Subsequent periods of eolian sand deposition apparently occurred during periods of high and low lake level, suggesting that the causes of dune growth are complex. A distinct drought at ~ 1 ka may have contributed to a major period of dune activation at that time. Dune ages are time-transgressive, with progressively younger deposits closer to the shore. Thus, it appears that isostatic rebound is a key component regarding dune formation and preservation in the northern part of Lake Michigan.

Keywords: Lake Michigan, Sand dunes, Sediment control.

AREND, K.¹, HOOK, T.¹, LUDSIN, S.A.², RUCINSKI, D.K.³, BELETSKY, D.⁵, DEPINTO, J.V.³, SCAVIA, D.⁴, and SCHWAB, D.J.⁶, ¹Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN, 47907; ²Aquatic Ecology Lab, Dept. of Evolution, Ecology, and Organismal Biology, The Ohio State University, Columbus, OH, 43212; ³LimnoTech, 501 Avis Dr., Ann Arbor, MI, 48108; ⁴School of Natural Resources and the Environment and Michigan Sea Grant, University of Michigan, Ann Arbor, MI, 48109; ⁵CILER - School of Natural Resources and the Environment, University of Michigan, 4840 S. State Rd., Ann Arbor, MI, 48108; ⁶NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48108. **Comparing Effects of Hypolimnetic Hypoxia on Yellow Perch and Rainbow Smelt Habitat Suitability in Central Lake Erie.**

Recent increases in the extent and duration of hypoxia in Lake Erie's central basin potentially threaten the production of economically and ecologically valuable fish species, such as yellow perch (*Perca flavescens*) and rainbow smelt (*Osmerus mordax*). We used limnological hindcasts (1987-2005) to evaluate the negative effects of hypoxic conditions on yellow perch and rainbow smelt habitat quality. We generated spatio-temporally explicit estimates of bioenergetic growth rate potential (GRP) to identify inter-annual variability in the quality of yellow perch and rainbow smelt habitat. We expected hypoxia to have a greater negative impact on habitat quality for rainbow smelt compared to yellow perch due to species-specific differences in oxygen and temperature tolerances. Indeed, yellow perch demonstrate positive GRP values across a broader range of depths than rainbow smelt, which are less tolerant of warm, epilimnetic water temperatures and low, hypolimnetic dissolved oxygen levels. To assess whether hypoxia appears to have any population-level effects on recruitment of both species, we related annual indices of habitat quality to fisheries independent estimates of year-class strength and recruitment to the fishery. *Keywords: Bioenergetics, Hypoxia, Lake Erie, Rainbow smelt, Yellow perch.*

ASHTON, D.M., The University of Toledo, 2401 W. Bancroft St., Toledo, OH, 43606. **Film, Video, and Environmental Science.**

Two of the most radical changes that have occurred in the last 20 years – and even moreso in only the last five to ten years – are exponential advances in audio/visual capture and dissemination technology and the rapid increase in public interest in our environment. With this paper I will explore the intersection between these two trends and discuss what it means to people of science. Whether audio/visual recording and distribution means the simplest documentation of an experiment, a news story, the production of a television show, the making of a documentary, the posting of a webcast, or the production of a fictional feature film on environmental issues, it is those closest to the research itself, those most intimate with the facts, that should be keenly aware of the importance of public awareness, the technological capabilities and venues of distribution available, the cultural and societal impact of subject and aesthetic choices, the reception of audiences, as well as the moral issues and value judgments involved. We have become a media dependent as well as a media savvy society. Those in environmental studies should have the opportunity to understand and utilize audio-visual communication in all its forms. *Keywords: Public education, Environmental education, Media.*

ATILLA, N.¹, MCKINLEY, G.A.¹, BENNINGTON, V.¹, URBAN, N.R.², WU, C.H.³, and DESAI, A.¹, ¹University of Wisconsin-Madison, 1225 West Dayton St, Madison, WI, 53706; ²Michigan Technological University, 870 Dow Environmental Science and Engineering Building, Houghton, MI, 49931; ³University of Wisconsin-Madison, 1415 Engineering Drive, Madison, WI, 53706. **Observed Dynamics of Surface pCO₂ in Lake Superior.**

Carbon fluxes from large water bodies may be important to understanding regional and continental carbon budgets. The Laurentian Great Lakes, with a surface area that comprises 3% of the continental United States may play an important role in the continental carbon budget, particularly in the upper Mid West, a region of focus by the North American Carbon Program (NACP). We examine mechanisms of carbon fluxes from Lake Superior at small and large spatial and temporal scales using available data. In the western arm, we consider the relationship between temperature, biological activity and pCO₂ at daily to monthly time scales during the summer of 2001. We find that springtime pCO₂ is determined predominantly by temperature, but after the Lake warms and stratifies, biological activity can draw down CO₂ and rapidly decrease near-surface pCO₂. The magnitude of the lake-wide flux is considered using a reanalysis of biannual lake-wide surveys from the USEPA and is coupled with an assessment of our current understanding of terrestrial carbon inputs. We link our analysis to a coupled physical-biogeochemical model of the Lake to improve our understanding of the lake carbon budget, its spatial and temporal variability, and to quantitatively improve the carbon budget. *Keywords: Carbon cycle, Lake Superior.*

BACH, C.A., Toronto and Region Conservation Authority, 5 Shoreham Drive, Downsview, ON, M3N 1S4. **Addressing Challenges to the Ecological Integrity of the Toronto Harbour through Collaboration.**

Aquatic Habitat Toronto, AHT, implements the Toronto Waterfront Aquatic Habitat Restoration Strategy, TWAHRS, conserving, restoring and creating habitat that was historically degraded. AHT represents a partnership between agencies with an interest in a healthy, self-

sustaining aquatic community on the Toronto Waterfront. The partners represent three levels of government and include Fisheries and Oceans Canada, Environment Canada, Ministry of Natural Resources, Toronto and Region Conservation, City of Toronto and Waterfront Toronto. The integrated planning approach streamlines approvals, and uses science to support regulatory decision-making to improve the chemical, physical and biological integrity of the aquatic system in keeping with TWAHRS and Remedial Action Plan objectives. Recently, 2500 m² of habitat was installed at Spadina Slip and construction will begin later this year to create a 5 ha coastal wetland. The Strategy strives to create a sustainable waterfront using an ecosystem approach to increase ecological integrity, to provide suitable conditions for the maintenance of self-sustaining aquatic communities and to improve ecological connectivity. It takes into account human uses of the shoreline and nearshore waters and was developed using a consultative, consensus-based approach involving stakeholders and the public *Keywords: Decision making, Fish, Great Lakes basin.*

BAI, X.¹ and WANG, J.², ¹CILER, University of Michigan, Ann Arbor, MI, 48108; ²Great Lakes Environmental Research Lab., NOAA, Ann Arbor, MI, 48108. **The Impacts of ENSO and AO on the Interannual Variability of the Great Lakes Ice Cover.**

The impacts of ENSO and AO on the Great Lakes ice cover were investigated using lake ice observations for winters 1963-2008 and NCEP reanalysis data. It is found that both ENSO and AO have impacts on the Great Lakes ice. During El Niño events, the Great Lakes tend to have less ice. Strong El Niño events are often associated with least ice cover. The impacts of La Niña events on the Great Lakes ice are insignificant. The Great Lakes tend to have less ice during +AO and more ice during -AO. The combination and interference of these two forcings complicate the relationship between the Great Lakes ice cover and ENSO (AO). When a winter is simultaneously during El Niño and +AO, the combined effects lead to mild winter. When a winter is during La Niña and -AO, the combined effects lead to severe winter. When a winter is simultaneously during El Niño and -AO, ice conditions on the Great Lakes depend on strengthen of these two forcings. When a winter is during La Niña and +AO, as the impacts of La Niña events on the Great Lakes are insignificant, the Great Lakes is dominated by +AO, leading to mild winter. These two states reinforce the asymmetric response of the Great Lakes regional climate to ENSO. The combination and interference of effects of both ENSO and AO should be considered to predict ice variability on the Great Lakes. *Keywords: Climates, Ice, Atmospheric circulation.*

BAJC, A.F., BURT, A., and KELLY, R.I., 933 Ramsey Lake Road, Sudbury, ON, P3E 6B5. **The Ontario Geological Survey's Surficial Aquifer 3-D Mapping Program.**

The Ontario Geological Survey (OGS) is undertaking region specific surficial aquifer 3-D mapping to provide geoscience information for the identification, protection, preservation and sustainable use of the provincial groundwater resource. Three-dimensional mapping involves characterizing the geometry and inherent properties of sand and gravel aquifers and clay and till aquitards overlying bedrock. Project results are released on CD-ROM and include; a summary of geology, procedures and protocols involved in constructing 3-D geologic models, the geometry

and properties of the main hydrostratigraphic units modelled, structural contour and isopach maps, cross sections and depth to aquifer maps to assess aquifer vulnerability and recharge. The CD-ROM also includes; PDF versions of all cross-sections and maps, text files of modelled surfaces, ArcInfo® structural contour grids of discontinuous surfaces, abridged versions of subsurface databases, a beta cross-section viewer and files for viewing data in a Google™ Earth environment. Information obtained in 3-D mapping can aid groundwater identification, extraction, protection and remediation studies, assist in developing land-use policies and help understand the interaction between surface and groundwater systems.

Keywords: Hydrogeomorphology, Surficial geology, Drinking water, Groundwater, GIS, 3-D modelling.

BAKER, C.L., 933 Ramsey Lake Road, Sudbury, On, P3E 6B5. **Ontario's Groundwater Mapping Program.**

In order to delineate and assess Ontario's overburden and bedrock aquifers the Ontario Geological Survey has established a multifaceted groundwater mapping program in the province's portion of the Great Lakes basins. Components of the program involve the integrated use of geologic mapping, stratigraphic investigations, geochemical/geophysical surveys and numeric modelling. Primary thrusts of the program include: determining the regional extent and character of aquifers; identification of new potable groundwater sources; and understanding water quality in the terrestrial portion of the Great Lakes basins. The products generated by the program directly contribute to the management of groundwater resources and an understanding of the physical environment. For example: knowledge of aquifer-aquitard relationships allow realistic vulnerability assessments which in turn influences land use planning decisions; groundwater withdrawals are determined on the ability of the aquifer to sustain production; and population growth centres are accessing aquifers discovered by geologic investigations and modeling. Further, the geochemical survey components are establishing regional ambient groundwater/stream sediment parameters to determine anthropogenic influences and delineate areas of potential health concerns and environmental impact. *Keywords: Groundwater mapping, Geochemistry, Decision making.*

BAKER, D.B., RICHARDS, R.P., and KRAMER, J.W., Heidelberg University, 310 East Market Steet, Tiffin, OH, 44883. **A Comparison of Trends in Total Phosphorus and Bioavailable Phosphorus Export from the Maumee and Sandusky Rivers, 1975-2008.**

In the 1980s phosphorus target loads for Lake Erie were established based on total phosphorus (TP) loads. While the target loads for TP have largely been achieved, Lake Erie responses have not followed expectations. This has prompted a reexamination of phosphorus loading to determine whether bioavailable phosphorus loads have followed the same trends as TP loads. TP loads are composed of two major fractions, total particulate phosphorus (TPP) and total soluble phosphorus (TSP). Bioavailable particulate phosphorus can be approximated by NaOH extraction; bioavailable dissolved phosphorus can be approximated by the dissolved reactive phosphorus portion of TSP. Measurements in 2007 indicated that about 25% of the TPP is bioavailable and about 90% of the TSP is bioavailable. These percentages agree closely with

similar measurements taken in the early 1980s. However, the proportions of the TP comprised of TPP and TSP have changed dramatically during the period of record, resulting in a minimum of bioavailable loading in the mid-1990s with a maximum of bioavailable loading in recent years. This pattern is caused by steadily decreasing TPP loads coupled with initially declining TSP loads followed by rapidly increasing TSP loads. Efforts to reduce TSP loads seem warranted.
Keywords: Phosphorus, Pollution load, Eutrophication.

BANDA, J.A. and STEPIEN, C.A., 6200 Bayshore Rd, Oregon, OH, 43618. **Fourteen Years of Genetic Structure in Lake Erie Walleye.**

Walleye *Sander vitreus* is the most important exploited Lake Erie fish, whose genetic stock structure is important to resource management. Past research shows that the genetic composition of walleye spawning in Lake Erie tributary and reef sites significantly differs. Using high-resolution nuclear microsatellite markers, the present study is the first to test whether the genetic composition of walleye spawning population groups is temporally stable. We employ 15 nuclear microsatellite loci to test the genetic structure of ~1500 walleye spawning in the Maumee, Sandusky, Grand (OH), and Grand (ON) Rivers, Van Buren Bay, Cattaraugus Creek, and Lake St. Clair across 14 years. Preliminary results show consistency among the Maumee River walleye runs in 1995, 1998, 2005, 2006, 2007, and 2008, with 2003 being significantly different. Similarly, the Sandusky River runs in 1995, 1998, 2005, 2007, and 2008 are congruent and differ from 2003. The 2003 Spawning groups in Van Buren Bay versus the Maumee, Sandusky, and Grand (OH) Rivers showed unusually high inter-run gene flow. The 2003 year class was the most successful in decades, and possible correlation with high gene flow is further examined. Our investigation thus illustrates the importance of testing temporal patterns of genetic variation to understand stock structure *Keywords: Lake Erie, Walleye, Genetics.*

BANTELMAN, A.¹, EDWARDS, W.J.¹, SOSTER, F.², SCHLOESSER, D.W.³, and MATISOFF, G.⁴, ¹Department of Biology, Niagara University, Lewiston, NY, 14109; ²Department of Geology, DePauw University, 602 South College Avenue, Greencastle, IN, 46135; ³USGS, Great Lakes Science Center, 1451 Green Road, AnnArbor, MI, 48105; ⁴Department of Geological Sciences, CWRU, 112 A.W. Smith Bldg, Cleveland, OH, 44106.
Role of Environment on Burrow Irrigation and Oxygen in *Chironomus* spp.

Chironomus spp. have a large potential impact on Lake Erie hypoxia via burrow irrigation through anoxic sediment. However, it is unclear how changing seasonal environmental conditions alter burrow irrigation and thus their potential impact on hypoxia. We conducted laboratory experiments to determine the effects of changing oxygen, food and temperature on both burrow irrigation activity and oxygen depletion. Mud and larvae were collected in the summer 2008 from Lake Erie. Forth instar larvae were placed in two dimensional mesocosms in defaunated sediment. After acclimation, larvae were exposed to changing food, temperature and oxygen regimes. Burrow velocities were measured using hot film anemometry and incurrent and excurrent oxygen concentrations were measured using Clark style micro electrodes. Oxygen depletion increased irrigation activity but decreased total oxygen depletion. Higher temperatures resulted in higher pumping activity, but decreased total depletion due to changes in oxygen

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

saturation with temperature. Food quantity did not affect burrow irrigation but did increase total oxygen depletion, likely due to increased bacterial respiration. These results indicate changing temperature, oxygen and food availability in the hypolimnion will require more complex modeling to estimate the impact of macrobenthos on hypoxia. *Keywords: Benthos, Oxygen, Water quality.*

BARBIERO, R.P.¹, BALCER, M.D.², WARREN, G.J.³, and LESHT, B.M.⁴, ¹Loyola University Chicago and Computer Sciences Corporation, 1359 W. Elmdale Ave. Suite 2, Chicago, IL, 60660; ²Lake Superior Research Institute, University of Wisconsin-Superior, PO Box 2000, Superior, WI, 54880; ³USEPA Great Lakes National Program Office, 77 W. Jackson Boulevard, Chicago, IL, 60604; ⁴Dept. of Earth and Environmental Sciences, University of Illinois Chicago, 845 W. Taylor St., Chicago, IL, 60607. **Recent Changes in the Lower Food Web of Lake Huron.**

Cladoceran populations in the open waters of Lake Huron declined abruptly in 2003 and have since remained at historically low levels. The two dominant cladocerans, *Daphnia mendotae* and *Bosmina longirostris*, have been nearly extirpated from the northern region of the lake, and are present in only slightly greater numbers in the south. Average non-predatory cladoceran biomass in the lake has declined over 90% between 1998-2002 and 2003-2006. In addition, historically unprecedented declines in cyclopoid copepods were seen in the lake in 2005. These changes have occurred against the backdrop of declining nutrient levels in the lake, and have coincided closely with declines in the amphipod *Diporeia*. In addition, satellite data suggest notable reductions in the intensity of the spring bloom in Lake Huron, beginning in 2003. We speculate that a combination of reduced primary production in the open waters and intensified planktivory due to the continuing disappearance of *Diporeia* has accounted for the losses in crustacean biomass seen in recent years. *Keywords: Zooplankton, Trophic level, Diporeia.*

BARBIERO, R.P.¹, BUNNELL, D.B.², WARREN, G.J.³, and LESHT, B.M.⁴, ¹Loyola University Chicago and Computer Sciences Corporation, 1359 W. Elmdale Ave. Suite 2, Chicago, IL, 60660; ²U.S. Geological Survey, Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105; ³USEPA Great Lakes National Program Office, 77 W. Jackson Boulevard, Chicago, IL, 60604; ⁴Dept. of Earth and Environmental Sciences University of Illinois Chicago, 845 W. Taylor St., Chicago, IL. **Recent Shifts in the Zooplankton Community of Lake Michigan.**

Since 2004, population density of the large hypolimnetic calanoid *Limnocalanus macrurus* has increased dramatically in Lake Michigan. The average summer biomass of this species between 2004-2006 was roughly three times that of the period 1984-2003, and at levels unprecedented in our 22-year dataset. These increases have been accentuated by coincident population declines of the main daphnid, *Daphnia mendotae*, in the lake with the result that in 2006, *L. macrurus* accounted for over 50% of the large (> 0.9 mm) crustacean biomass in the lake. The increases in *L. macrurus* populations have closely coincided with equally dramatic increases in summer water clarity. Recent extinction coefficients are among the lowest recorded

for the lake, and deepening light penetration has permitted increases in the size of the deep chlorophyll layer. In addition, planktivorous fish populations have declined coincident with the increases in *L. macrurus*. It seems likely an increase in sub-epilimnetic production has resulted in increased food resources for the deep-living *L. macrurus*, while low planktivore abundances have reduced predation loss, permitting *L. macrurus* to respond to these increases in sub-epilimnetic production. *Keywords: Lake Michigan, Zooplankton, Productivity.*

BARTON, N.T.¹, CLARAMUNT, R.M.², GALAROWICZ, T.L.¹, and FITZSIMONS, J.D.³,
¹Central Michigan Department of Biology, 146 Brooks Hall, Mount Pleasant, MI, 48858;
²Michigan Department of Natural Resources, Charlevoix Fisheries Research Station, 96 Grant Street, Charlevoix, MI, 49720; ³Great Lakes Laboratory of Fisheries and Aquatic Sciences, Bayfield Institute, Post Office Box 5050, Burlington, ON, L7R 4A6. **Comparing Lake Trout and Lake Whitefish Selection of Microhabitat Spawning Sites: Implications for Native Fish Rehabilitation.**

Native Great Lakes fishes such as lake trout (*Salvelinus namaycush*) and lake whitefish (*Coregonus clupeaformis*) use reefs for spawning in the Great Lakes. However, the specific areas, habitat characteristics, abiotic conditions, and timing of spawning by each species is not well known. Habitat evaluations were conducted prior to sampling adults or eggs during the fall spawning period in 2008. Two gear types, egg bags and egg funnels, were used to measure egg deposition rates to determine site selection by spawning fish. In addition, the efficiency of the egg bags and eggs was measured by seeding each gear type with artificial beads in situ. Egg funnels were more efficient because they could be checked on a weekly basis while the egg bags collected one sample between deployment and retrieval. However, estimates of natural egg deposition from egg bags were higher than the funnel estimates likely resulting from gear avoidance or other limitations. Accurate estimates of native fish egg deposition rates and spawning habitat use will assist fisheries managers in making more informed decisions for management actions such as stocking and habitat protection. *Keywords: Lake trout, Spawning site, Fish management.*

BASU, N., Department of Environmental Health Sciences, University of Michigan, Ann Arbor, MI, 48109, US. **Muscarinic Cholinergic Receptors as a Novel Biomarker for Methylmercury - Evidence from Animals, Implications for Humans.**

Recent work in our laboratory has determined that one of the earliest and most consistent biochemical responses in methylmercury-exposed organisms is a significant increase in the levels of brain muscarinic cholinergic receptors. Findings were made in vitro and in vivo, in animals exposed both in the laboratory and through natural pathways, and in fish, birds, and terrestrial mammals from the Great Lakes region and beyond. To establish a causal link between methylmercury exposure and increased brain muscarinic cholinergic receptors the collective results from our studies are collated and synthesized under an eco-epidemiological framework (probability, strength of association, specificity, consistency, predictive performance, coherence). By incorporating the aforementioned studies into these criteria, a holistic analysis reveals that increases in brain muscarinic cholinergic receptor levels provide an early warning of

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

methylmercury's risk. The mechanistic basis for this relationship will be described by fusing the in vitro and in vivo findings. Since muscarinic cholinergic receptors exist on blood lymphocytes, their use as novel biomarkers in human studies is an exciting prospect that will be discussed.

Keywords: Methylmercury, Ecosystem health, Environmental health.

BECKER, R.H.¹, SULTAN, M.I.², BOYER, G.L.³, and TWISS, M.R.⁴, ¹University of Toledo, 2801 W Bancroft Ave, Toledo, OH, 43606; ²Western Michigan University, 1903 W Michigan Ave, Kalamazoo, MI, 49008; ³SUNY - College of Environmental Science and Forestry, 1 Forestry Drive, Syracuse, NY, 13210; ⁴Clarkson University, 8 Clarkson Ave, Potsdam, NY, 13699. **Using MODIS to Map Cyanobacteria in Lake Erie.**

Toxin producing cyanobacteria have been documented in the Western Basin of Lake Erie multiple times throughout the last several years. An algorithm was developed to distinguish between potentially toxic cyanobacterial blooms from other harmless blooms and to quantify phycocyanin abundances from Moderate Resolution Imaging Spectrometer (MODIS) satellite data. Lee's Quasi-Analytical Algorithm is used to calculate total absorption from the 250 m, 500 m and 1 km bands of MODIS scenes. A nonnegative least square algorithm is then utilized to calculate the relative concentrations of green algae, blue-green algae, and CDOM and sediments combined in lake waters using published absorption spectra and the satellite derived absorption images. MODIS-derived cyanobacterial concentrations at 1km spatial resolution were calculated from satellite images during blooms acquired in the summers of 2004 and 2005 were successfully verified against contemporaneous calibrated measurements of pigments that were acquired from along track fluorometer measurements from six cruises, and additional cyanobacterial blooms reported in the scientific literature between 2002 and 2007.

Keywords: Cyanobacteria, Lake Erie, Lake Erie, Satellite technology.

BELETSKY, D.¹ and SCHWAB, D.J.², ¹CILER, SNRE, University of Michigan, 2205 Commonwealth Blvd, Ann Arbor, MI; ²NOAA Great Lakes Environmental Research Laboratory, 2205 Commonwealth Blvd, Ann Arbor, MI. **Climatological Circulation in Lake Michigan.**

Maps of climatological circulation in Lake Michigan are presented for the first time. They are based on ten years continuous modeling of lake hydrodynamics from 1998-2007 using observed meteorological data as the forcing function. Model results show a remarkably stable large-scale cyclonic circulation pattern during both stratified and unstratified conditions. Lake-averaged mean current speed is about 2 cm/s, but currents can reach 10 cm/s in some locations. The model results are confirmed by long-term current observations.

BELETSKY, D.¹ and SCHWAB, D.J.², ¹CILER, University of Michigan, Ann Arbor, MI; ²NOAA Great Lake Environmental Research Laboratory, Ann Arbor, MI. **Modeling Summer Circulation in Lake Huron.**

A 3-dimensional circulation model of Lake Huron is used to calculate lake circulation and thermal structure in 1992-1993 on a 2 km grid. The model is based on the Princeton Ocean Model of Blumberg and Mellor (1987). The hydrodynamic model of Lake Huron has 20 vertical levels with finer spacing near the surface and the bottom. Momentum and heat fluxes are derived from hourly observations obtained from meteorological stations around Lake Huron and NDBC buoys. Model results show existence of an anticyclonic gyre near the entrance of Saginaw Bay in summer, impacting water exchange between the lake and the bay. 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.

BHAVSAR, S.P.¹, GEWURTZ, S.², LABENCKI, T.L.¹, HELM, P.A.¹, MARVIN, C.H.³, FLETCHER, R.¹, HAYTON, A.¹, REINER, E.J.¹, and BOYD, D.¹, ¹Ontario Ministry of the Environment, Toronto, ON; ²University of Toronto, Toronto, ON; ³Environment Canada, Burlington, ON. **Connecting Fish Consumption-Advisories and Sedimentary PCBs in the Canadian Great Lakes.**

Sediment quality guidelines (SQGs) have been developed to protect aquatic biota. However, since humans are exposed to sedimentary contaminants through consumption of fish, SQGs that would result in fish concentrations below consumption advisory levels should be considered. To illustrate how this can be addressed, we first calculate Biota Sediment Accumulation Factors (BSAFs) for total-PCB and dioxin/furan in the Canadian Great Lakes using measured lake sediment and fish concentrations. Using these BSAFs and fish consumption guidelines of the Ontario Ministry of the Environment (OMOE), we derive human fish consumption-based SQGs (hfc-SQGs), which are likely to result in fish concentrations that are safe to eat without restriction. The dioxin/furan hfc-SQGs ranged from 0.1-18 pg TEQ/g and were generally close to or above the Canadian Council of the Ministers of the Environment (CCME)'s Threshold Effect Level of 0.85 pgTEQ/g. In contrast, the total-PCB hfc-SQGs ranged from 1-13 ng/g and were below the CCME's TEL of 34.1 ng/g and OMOE's Lowest Effect Level of 70 ng/g; however, they were consistent with the OMOE's No Effect Level of 10 ng/g. The hfc-SQGs presented here can assist environmental decision makers in designing policies and taking management actions that are protective of both aquatic biota and fish consuming human.
Keywords: Fish, Sediments, PCBs.

BHAVSAR, S.P., AWAD, E., FLETCHER, R., and MOODY, R., Ontario Ministry of the Environment, Toronto, ON. **Mercury in Canadian Great Lakes Fish: A Concern?**

Most of the fish consumption advisories issued for the Canadian Great Lakes by the Ontario Ministry of the Environment (OMOE) are due to elevated levels of dioxin-like PCBs and dioxins/furans. Since OMOE issues fish consumption advisories based on the most restrictive contaminant, it is not clear whether the current mercury levels would restrict fish consumption if largely anthropogenically derived PCBs/dioxins/furans were to decrease below their consumption guidelines. In order to explore this, we analyzed OMOE mercury measurements for all Canadian Great Lakes fish species tested from 2000-2007, and compared their levels with the OMOE fish consumption guidelines. Mercury levels in all species and size ranges sampled from

individual lakes resulted in unrestricted (8 meals/month) or moderate restriction (4 meals/month) on consumption for the general population, with the exception of large sized (>75cm) Lake Ontario walleye which had more severe consumption restrictions (2 meals/month). However, a number of advisories for the sensitive population (women of child-bearing age and children under 15) resulted in partial or complete restrictions (i.e., no consumption). These results provide lake-wide mercury advisory overviews; however, local conditions in each lake may result in more severe consumption restrictions. *Keywords: Fish, Mercury, Consumption advisories.*

BIDLEMAN, T.F.¹, KURT-KARAKUS, P.B.¹, JANTUNEN, L.M.¹, MUIR, D.C.G.², TEIXEIRA, C.², CAGAMPAN, S.J.², STRUGER, J.², SVERKO, E.², SMALL, J.², DOVE, A.², and BACKUS, S.², ¹Science and Technology Branch, Environment Canada, 6248 Eighth Line, Egbert, ON, L0L 1N0; ²Science and Technology Branch, Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Exchange of Metolachlor between Great Lakes Air and Water.**

Metolachlor is a herbicide used on corn and soybeans and to a lesser extent on vegetable crops. Metolachlor ranked within the top 10 pesticides applied in Canada during 2003, with a usage of 556 tonnes. Nearly 98% of this usage occurred in Ontario. Metolachlor is also heavily used in the U.S. portion of the Great Lakes basin, 1110 tonnes in 2002. Metolachlor has been measured in Ontario streams, surface water of all five Great Lakes, precipitation and air. This paper provides estimates of metolachlor exchange using available water concentration measurements and air data from land-based stations, and paired water/air measurements in and over Lake Ontario. Metolachlor consists of four stereoisomers; two are herbicidally active (S-isomers) and two are not (R-isomers). Older racemic metolachlor products have S/R ratios ~1, while newer S-metolachlor products are enriched in the active isomers with S/R ~7.5-9. Differing S/R ratios in rivers, lakes and atmospheric samples provide clues to metolachlor sources and environmental fate. *Keywords: Air-water interfaces, Pesticides, Atmosphere-lake interaction.*

BLAIR, C.A., Ohio EPA, 347 N. Dunbridge Rd., Bowling Green, OH, 43402. **Highland Park Dam Decommissioning and Riparian Project for Swan Creek.**

This project responds to another common problem in Great Lakes tributaries. The PCS and the Maumee RAP will test and demonstrate a new technology in dam mitigation. Obsolete dams are found throughout the region, and increasingly are being removed for public safety, improved fish habitat, and recreational opportunities. However, when dams cannot be removed, new technologies have been developed to achieve the same purposes. The PCS & its partners propose to decommission and remediate Highland Park Dam, a low dam in metropolitan Toledo that prevents fish from spawning, traps sediments, and degrades water quality. Because the dam cannot be removed, the solution proposed is to build structures into the streambed that would restore natural water movement and allow spawning fish to swim over the dam. Water temperature and plants—both important for fish—would become more natural as a result. The construction of this project was completed in August 2008 and an overview of the design and installation will be provided along with preliminary comments and observation as to

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

opportunities for water quality and fish habitat improvements. *Keywords: Watersheds, Ecosystems, Management.*

BLATZ, C.V., Dept. of Philosophy, University of Toledo, 2801 W. Bancroft St., Toledo, OH, 43606. **Questions of Ethics In Environmental Science and Environmental Studies Education.**

What place do ethics have in our attention to the unbuilt environment? This question conceals others. Regarding the ways and extent ethics appear in human attention: first, how and how much are humans ethically concerned; second, how much and in what ways should humans be ethically concerned as they intervene in natural systems? Regarding the content of the concern about the environment: first what ethical concerns do humans respond to; second, what should humans be concerned with ethically? Regarding what humans do and what they should do about bringing ethics into their reflections: what is possible or how good can humans be; and, what ethical guidance can be found for making us as ethical as we can be? All of the first items in these pairs are factual questions for the social sciences. All of the second items are normative or ethical questions. The normative items are addressed systematically nowhere else than in the study of environmental ethics and environmental philosophy. For this reason the University of Toledo requires undergraduates to engage in these studies in an environmental ethics class. This session reports on this class, the normative reflection that shapes it, its forms, its service learning component, and its aims to help the thinking of both citizens and professionals without being doctrinaire. *Keywords: Environmental ethics, Environmental education.*

BLOSSER, J.¹ and CRAIL, T.D.², ¹Scott High School, 2400 Collingwood, Toledo, OH, 43620; ²The University of Toledo-Department of Environmental Sciences, The Lake Erie Center, Toledo, OH, 43606. **Student-Based Ecological Monitoring of Two Riffle classes in Swan Creek, an Urban Stream in NW Ohio.**

Ecological monitoring of urban systems may engage high school students in understanding the importance and complexity of ecological systems. As a part of the 2008-2009 area-wide Student Watershed Watch and our National Science Foundation GK-12 program, our high school junior and senior students began monitoring two riffle types in Swan Creek, an increasingly urban watershed in northwest Ohio. Our riffle types were determined by age; one, an existing riffle, the other, a riffle constructed in September 2008 as a restoration project to allow fish passage over a lowhead dam. Our students measured water quality parameters (inorganic nutrients, turbidity, dissolved oxygen, temperature, pH, and fecal coliforms) and sampled macroinvertebrates and fish with kicknets and seines, respectively. They determined importance values for water quality, identified invertebrates (existing riffle-8 orders, new-2 orders) and fish (existing-14 species, new-0 species), and formed hypotheses about the previous night's rainstorm effects on these values. Select students will continue monitoring in spring and summer 2009 to identify and document colonization of the constructed riffle and, possibly, assist with instruction in the fall 2009 class project. *Keywords: Urban watersheds, Monitoring, Water quality.*

BOCANIOV, S.A.¹, SMITH, R.E.H.¹, and SCHIFF, S.L.², ¹Department of Biology, University of Waterloo, Waterloo, ON, N2L3G1, Canada; ²Department of Earth and Environmental Sciences, University of Waterloo, Waterloo, ON, N2L3G1, Canada. **Plankton Metabolic Balance and Physical Forcing in Lakes: Insights from Stable Oxygen Isotopes.**

The plankton metabolic balance, commonly indexed by the photosynthesis to respiration ratio (P/R), has received much attention in connection with allochthonous organic subsidies in lakes while the role of physical, climate-related, forces have received less attention. Here we used isotope (¹⁸O) and bottle methods to estimate P, R and P/R at four coastal sites of different productivity and physical exposure in the Laurentian Great Lakes to test the hypothesis that physical forcing events, particularly wind and upwelling episodes, significantly affect P/R. At the most energetic site the isotope model was not reliable; however, at the sites with the lower physical exposure, estimates of P, but not R, from the isotope model were significantly correlated with bottle estimates while average P/R was similar by both methods. Closer examination at a productive site with pronounced physical forcing led to a model of how wind events induce mixing, upwelling, exchange and consequent changes in P and R. These physical forcing events were captured more by the isotope model than by the bottle estimates, as episodes of immediately increased R and decreased P/R, with a subsequent stimulation of P.

Keywords: Physical forcing, Respiration, Photosynthesis.

BODAMER, B.L.¹, BRIDGEMAN, T.B.¹, RUCH, R.J.², and HOOK, T.³, ¹The University of Toledo-Department of Environmental Science, The Lake Erie Center, Toledo, OH; ²The University of Toledo-Health Science Campus, Departments of Biochemistry and Cancer Biology, Toledo, OH; ³National Oceanic and Atmospheric Administration, Ann Arbor, MI. **Measuring Hypoxia-Induced Physiological Stress in Yellow Perch (*Perca flavescens*).**

The seasonal hypoxic zone of central Lake Erie creates a potential barrier between benthic foraging fish and their primary food source. Previous studies have suggested that yellow perch (YP) often roam above the hypoxic hypolimnion, making short forays to the bottom to forage; however, the physiological stresses and behavioral changes undergone by benthic foraging fish in hypoxic conditions are unclear. To better understand the effects of hypoxia on benthivorous fish, we evaluated several potential hypoxia markers (proteins known to accumulate under hypoxic conditions) in YP. In a controlled experiment, YP were subjected to high, moderate, and low oxygen concentrations for varying lengths of time. Liver and gill tissues were then harvested for analysis. Potential markers (rat HIF-1a, piscine HIF-1a and HIF-4a, and VEGF) were evaluated using Western Blots to quantify protein content under varying levels of hypoxia. In liver tissues, piscine HIF-1a and VEGF proteins provided the best response to changes in oxygen concentration, while mammalian HIF-1a and piscine HIF-4a did not provide quantifiable results. No quantifiable results were obtained from gill tissue. The analysis of piscine HIF-1a and VEGF, as well as future directions and applications of this method, will be examined further. *Keywords: Yellow perch, Oxygen, Environmental effects.*

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

BOGUE, M.¹ and MILEYEVA-BIEBESHEIMER, O.², ¹Sylvania Northview High School, 5403 Silica Drive, Sylvania, OH, 43560; ²Department of Civil Engineering, The University of Toledo, Toledo, OH, 43606. **Student Water Quality Testing Engages Students in all Levels of Bloom's Taxonomy.**

Using the framework of Toledo Metropolitan Area Council of Government's (TMACOG) Student Watershed Watch (SWW), supported by the University of Toledo's National Science Foundation GK-12 program, Northview High School Environmental Science students work through all levels of Bloom's Taxonomy (knowledge, comprehension, application, analysis, synthesis, and evaluation). Students test the water quality of Ten-mile Creek, a small tributary that feeds into Lake Erie. Each student is given the opportunity to touch on all levels of Bloom's Taxonomy in the concepts and testing procedures of water quality. In-depth participation in the final two levels of Bloom's, synthesis and evaluation, is offered to all students involved -- a small percent of motivated students take on the challenge of evaluation by combining all the data, culminating in a presentation for TMACOG's SWW Summit. The students then proceed by designing a presentation that explains and analyzes the data, while incorporating the use of technology. As an added goal, the Northview students are directed to make the presentation entertaining as well as informative. Included information will consist of total number of participants, as well as presentation formats. Project details will be outlined to demonstrate the project goals and how they are achieved. *Keywords: Bloom's Taxonomy, Education, Water quality.*

BOLEN, W.J. and SCHARDT, J.C., 77 W. Jackson Blvd., Chicago, Il, 60604. **Invasive Species Rapid Response.**

Preventing the introduction of AIS is the first line of defense against invasions. However, even the best prevention efforts do not stop all AIS introductions. While it is recognized that early detection increases the likelihood that invasions will be addressed successfully while populations are still localized and can be contained and eradicated, more needs to be done in combining the the expertise of scientists into a cohesive Science Advisory Committee that can provide advice for responding authorities prior to, during, and after a response is taken. Response agency need to perform operational, planning, logistical, financial, and administrative functions. The guidance scientists, researchers, and policy advisors can provide is not in close alignment these functions. This alignment is critical to provide key governmental officials the information they need to direct their authorities to respond to a newly discovered or spreading Invasive Species. As an interim step toward improving AIS response capability, this presentation will introduce "Incident Command System" (ICS) concepts for the benefit of scientist who might participate in rapid response events, but who have not typically operated under such ICS structures. *Keywords: Planning, Invasive species, Mitigation.*

BOLLIN, T.¹, HAPONSKI, A.E.², and STEPIEN, C.A.², ¹Toledo Early College High School, 225 Nebraska Avenue, Toledo, OH, 43607; ²Department of Environmental Science/Lake Erie Center, The University of Toledo, Toledo, OH, 43606. **Collaborative Science Research**

Experience for High School Students with a Focus on Water Quality Testing on the Ottawa River Watershed.

The Toledo Early College High School (TECHS) and the University of Toledo's Lake Erie Center NSF-funded GK-12 program are partnering in a dual credit hands-on science research experience course. Ph.D. student Amanda Haponski's job in teacher Timothy Bollin's research classroom is to mentor students, promote their interest in science related degrees and careers, serve as a content expert in aquatic ecology, and help them to conduct a water quality study. Two sites on the Ottawa River about one mile apart were sampled for chemical, physical, and biological parameters as part of TMACOG's Student Watershed Watch program on October 16, 2008. Results showed that overall water quality at the two sites placed in the "medium" range, including D.O. (6.0 vs. 5.0 mg/L), pH (7.5 vs. 8), total P (0.125 vs. 0.64 mg PO₄/L), N (5.72 vs. 3.96 mg NO₃/L), and fecal coliform counts (6233 vs. 6600 CFUs/100 mL). Benthic macroinvertebrates showed low ("poor") diversity. This testing served as the focus for active exploration of research methodology in our classroom, engaging students in the scientific method through hypothesis generation, sampling design, data collection, analysis, interpretation, and drawing conclusions. Students then used this baseline experience to design and conduct independent research projects on related topics. *Keywords: Education, Water quality, Monitoring.*

BOOTSMA, H.A., SCHAFER, J.S., and FILLINGHAM, J.H., University of Wisconsin-Milwaukee, Great Lakes WATER Institute, Milwaukee, WI, 53204. **Influence of a Large Rain Event on Lake-Atmosphere Carbon Dioxide Exchange in Lake Michigan.**

Measurements of lake and atmospheric CO₂ concentrations that are highly resolved in space and time can provide novel insights into the mechanisms by which carbon dynamics are linked to physical forcing. However, collection of such data is expensive and logistically difficult using conventional sampling and analytical methods. We have circumvented this problem by deploying a continuous air/water CO₂ monitoring system on a high-speed ferry that crosses Lake Michigan up to six times daily. Deployment in the summer of 2008 coincided with a period of high rainfall and river discharge. The ferry-based monitoring system showed that this high discharge resulted in high CO₂ concentrations within 1 km of shore, but persistent low concentrations within a larger nearshore zone that expanded from a width of 10 km in mid-June to 50 km by early July. Lake-atmosphere CO₂ flux estimates indicate that the increased photosynthesis resulting from episodic nutrient loading events can make a significant contribution to the lake's annual carbon budget. *Keywords: Photosynthesis, Air-water interfaces, Carbon cycle.*

BOSCARINO, B.T., RUDSTAM, L.G., and MINSON, M.A., 900 Shackelton Point Road, Cornell Biological Field Station, Bridgeport, NY, 13030, USA. **Differences in Light Preferences of Juvenile and Adult Mysid Shrimp: Implications for Alewife Feeding Ecology.**

Light plays an important role in determining the degree of spatial overlap between mysid shrimp and alewife in the offshore of Lake Ontario. However, light may not influence the depth selection behavior of mysids in the same way for all members of the population. Juvenile mysids will often inhabit shallower depths and overlap to a greater extent with alewife than their adult counterparts and we hypothesize that these vertical distribution patterns are driven by different light responses of the age classes. To test this hypothesis, we compared the depth selection behaviors of juvenile mysids exposed to different light levels in the laboratory to those results obtained using adult mysids from Lake Ontario. Juvenile mysids both preferred and tolerated higher light intensities than adult mysids. The light level required to elicit an avoidance reaction in juveniles was over two orders of magnitude brighter than for adults and several orders of magnitude brighter than the minimum light level required by alewife to feed on mysids. These results suggest that juvenile mysids may be more accessible to alewife as a food resource than adult mysids and could explain the increased presence of mysids in the diet of alewife commensurate with increasing water clarity in the offshore of Lake Ontario. *Keywords: Alewife, Migrations, Zooplankton.*

BOSSENBROEK, J.M.¹, FINNOFF, D.², and IVERSON, L.R.³, ¹Dept. of Environmental Sciences, Lake Erie Center, Toledo, OH, 43606; ²Dept. of Economics and Finance, Laramie, WY, 82071; ³USDA Forest Service, Northeastern Research Station, Delaware, OH, 43066. **An Introduction to the Bioeconomics of Invasive Species with Examples from the Emerald Ash Borer Invasion.**

In a bioeconomic framework to address the threat of invasive species, one of the objectives is to provide estimates of the regional economic and ecological impact an invasive species will potentially inflict upon a region. Achieving this objective requires addressing six steps: 1) estimate the potential habitat, 2) predict the spread, 3) estimate economic and ecological impacts, 4) determine the regional consequences of spread through the economy and ecosystem, 5) determine cost and effectiveness of different prevention and control strategies, and 6) link distribution and spread models to optimize resources. We are currently using this framework to assess the potential economic impact of the emerald ash borer (*Agrilus planipennis*; EAB) invasion on Ohio and Michigan. Here we highlight models of EAB spread, estimates of the distribution of ash trees, estimates of regional and localized economic impacts, and predictions of the optimal timing and execution of strategies to control the spread of EAB on a regional basis. The objective of this research is to provide policy-makers with quantitative guidance for cost-effective alternative strategies to control, prevent, or slow the spread of emerald ash borer. *Keywords: Economic impact, Biological invasions, Model studies.*

BOSTON, T.J.¹, LU, X.¹, MUGALINGAM, S.², RODGERS, G.², and RUDRA, R.³, ¹Greenland International Consulting Ltd., Suite 304 - 15955 Airport Road, Caledon East, ON, L7C1H9, Canada; ²Trent Conservation Coalition, 714 Murray Street, R. R. #1, Trenton, ON, K8V 5P4, Canada; ³University of Guelph, School of Engineering, Guelph, ON, N1G 2W1, Canada. **Water Balance Quantification in the Trent River Watershed: Validation of Ungauged Tributaries and Impact of Storage Variables.**

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

The CANWET model uses GIS and time series meteorological data to generate continuous simulations of hydrology and water balance using a methodology based on the Generalized Watershed Loading Function model developed by Haith et al. (1992). The model was used to simulate tributaries to the Trent River composing approximately 13,000 km² of total drainage area. Hydrograph calibrations were undertaken for 10 tributaries. Soil, geologic and climate factors were found to produce characteristic flows between northern and southern portions of the study area. Categorizing tributary flows by region and degree of flow regulation, a probable range of long term average monthly flows was established to validate simulated flows for ungauged tributaries. Storage associated with the large number of lakes and undefined soils were found to merit special consideration in order to adequately estimate evapotranspiration. Simulated hydrology and water balance from tributaries agreed well with available data and simulations fell within the expected regional flow range for the ungauged streams. Results of the study were used to identify and quantify areas with water stress. Results of this and other studies are being used to improve the model for source water protection and climate change studies and initiatives. *Keywords: Computer models, Water balance, Validation.*

BOURLAND, D.¹, CAMPBELL, M.², and STIERMAN, D.J.², ¹Bowsher High School, 2200 Arlington Avenue, Toledo, OH, 43614; ²University of Toledo, Department of Environmental Sciences, 2801 W. Bancroft, Toledo, OH, 43606. **Using Ground Penetrating Radar to Locate Unmarked Graves in Toledo, Ohio, USA.**

A pauper's cemetery dating to 150 years ago was the burial location for the nearby public mental hospital in Toledo, Ohio. The property sits adjacent to Bowsher High School, a site easily accessed by students participating in NSF funded GK-12 research. It is known that the cemetery hosts many unmarked graves, but the numbers and boundaries of burial locations are uncertain. A magnetometer study at this site showed several small dipole anomalies some of which are associated with small marker stones. Ground penetrating radar (GPR) is a non-invasive method of detecting shallow subsurface features and has been used in many studies to detect unmarked graves. The objective of this project is to use GPR to support the possibility that dipole anomalies mark the locations of unmarked graves. Several north-to-south transects were completed with 200 MHz antennas, step size of 0.25m, and 0.5m separation. Transects were spaced 1.0m apart. Anomalies appeared on each transect with a possible pattern. The anomalies indicate ground disturbances that are comparable to the size of a grave. In conducting this project students engaged in unique research with observable societal impacts. This information will be used by the Toledo State Hospital Cemetery Reclamation Project to further their understanding of the site. *Keywords: Experimental design, Cemetery, Public education, GPR, Political aspects, Student research.*

BOWEN, K.L.¹, GERLOFSMA, J.¹, ARTS, M.T.², and ISAAC, E.J.³, ¹Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; ²Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; ³Biology Department, University of Minnesota Duluth, 207 Swenson Science Building 1035 Kirby Drive, Duluth, MN, 55812-3004. **Population Dynamics, Growth and Condition of *Mysis relicta* in Lake Huron.**

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

The opossum shrimp *Mysis relicta* fills an important intermediate position in the pelagic food web of the Great Lakes, but its status in Lake Huron is largely unknown. In 2007, we sampled mysids at four stations in spring, summer and fall using vertical net hauls, and did a lakewide survey in August. Mysids and zooplankton were also collected at the four stations to measure essential fatty acids and nucleic acid ratios. These are indicators of body condition and growth, and will be compared to data collected in 2002 and 2003. Initial nucleic acid results suggest Huron mysids remain in good condition. Mean abundance was low in May (24 mysids/m²) and increased through August (115/m²) and into October (151/m²). As with the other Great Lakes, abundance and biomass increased with depth. In 2007, gravid females were generally smaller than in 2002, and reproduced earlier in the year. Size distribution suggests lower predation on mysids in 2007, which likely relates to the alewife collapse reported in 2003. Although May and August densities were lower in 2007 than in 2002, there is no strong evidence of mysid collapse in Lake Huron. Mysid population and chemical indicator results will also be compared to a similar study conducted in Lake Superior in 2005. *Keywords: Mysids, Lake Huron.*

BOYER, G.L., SMITH, J.S., GIBSON, J.L., and SATCHWELL, M.F., Departments of Chemistry and Environmental Biology, SUNY-College of Environmental Science and Forestry, Syracuse, NY, 13210. **New Approaches for Assessing the Risk from Microcystin-Contaminated Fish.**

Large blooms of toxic *Microcystis* regularly occur in parts of Lakes Erie, Ontario, and Huron. Fish, feeding on those blooms can accumulate microcystin toxins in both their internal organs (liver) and tissues (muscle). These “free” microcystins are rapidly metabolized through either a glutathione-based detoxification pathway, or sequestered by the reaction between thiols and the Mdha amino acid to form “protein-bound” microcystins. This “bound” pool of microcystins can potentially be released as small microcystin peptide conjugates by the degradative enzymes found in higher trophic level consumers. These fragments are again inhibitory to protein phosphatases and may lead to increased risk from these toxins. Here we describe methods to monitor the movement of microcystins through these different metabolic pools. Free microcystins were measured using ESI-LCMS after addition of the internal standard (S-hydroxypropyl cyst7)-microcystin LR. Bound microcystins were measured by negative ion APCI LCMS after oxidation of the ADDA group to methyl, methoxy-phenylbutyric acid (MMPB) using chemical oxidants. The application of these techniques to fish tissues collected from microcystin-contaminated waters will be presented. *Keywords: Microcystis, Fish, Toxic substances, Risk assessment.*

BRAIG, E.C. and REUTTER, J.M., Ohio Sea Grant College Program, 1314 Kinnear Rd, Columbus, OH, 43212. **F. T. Stone Laboratory, The Ohio State University.**

Stone Laboratory, Ohio's Lake Erie Laboratory since 1895, is the oldest freshwater biological field station in the country and part of the Ohio Sea Grant College Program at The Ohio State University. Each summer approximately 25 college courses are taught at the Laboratory. Courses are offered at three levels: one-week introductory courses, one-week

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

courses for teachers, and 5-week courses for upper level undergraduate and graduate students. Since 1990, students in these courses have come from 104 different colleges and universities and 371 high schools (superior high school students are allowed to participate in the introductory courses and receive college credit while they are still in high school). During the spring and the fall the Laboratory offers field trips, workshops and conferences for grades 4 through adults with about 6,000 participants annually. Research goes on year-round with 20-30 projects addressing issues such as the dead zone in Lake Erie, harmful algal blooms, zebra mussels, water pollution and cleanup, and many projects to enhance the economic value of Lake Erie. The Laboratory is supported from a variety of sources including 16 endowments and the Friends of Stone Laboratory, and annually awards approximately 40 scholarships and 10 endowment-funded Research Experiences for Undergraduates. *Keywords: Lake Erie, Environmental education, Biological field stations.*

BRAIG, E.C.¹, GABRIEL, T.A.¹, APPLGATE, J.², and DORMAN, L.³, ¹Ohio Sea Grant College Program, Columbus, OH; ²US Fish & Wildlife Service, Reynoldsburg, OH; ³ODA-Division of Animal Industry, Reynoldsburg, OH. **Viral Hemorrhagic Septicemia (VHS) in Ohio: a Report on Inland Monitoring.**

VHS is a fish disease that caused substantial kills in Ohio's Lake Erie waters in 2006 as well as elsewhere in the Great Lakes region. Subsequently, the USDA-Animal & Plant Health Inspection Service restricted live interstate transport of susceptible fishes. In response, the Ohio Department of Agriculture (ODA) restricted live intrastate transport of those fishes inland from the waters of Lake Erie and initiated a monitoring effort to detect inland progression of the virus. Consulting with the ODNR-Division of Wildlife, ODA selected 22 high-risk sites spanning Ohio's seven major non-Lake Erie US Geologic Survey hydrologic unit codes. USDA sample protocols require the collection of 170 susceptible fish per site at water temperatures of 2-20° C to detect virus presence with 95% confidence. Ohio Sea Grant collaborated with the US Fish & Wildlife Service to collect the required specimens by electrofishing in autumn 2007 and spring 2008. Samples were delivered for cell culture and VHS testing by the ODA-Division of Animal Industry. All samples tested negative for the disease. We do not expect VHS to have substantial long-term impacts on large, wild fish populations. The disease is potentially more problematic to smaller, human-made impoundments and culture operations, especially where fish are crowded and/or stressed. *Keywords: Reservoirs, Fish diseases, Monitoring.*

BRAUER, S.R., U.S. EPA, Region 5, 77 West Jackson Boulevard (LR-8J), Chicago, IL, 60604. **NMN for Water Quality of Coastal Waters and Their Tributaries.**

What is the condition of the oceans? and the United States' coasts? Three United States White House Councils proposed an initiative to address U.S. Commission on Ocean Policy recommendations by developing a National water quality-monitoring network that includes coastal and upland areas and that links to the Integrated Ocean Observing System, or Great Lakes Observing System here in the Great Lakes Basin. The National water-quality monitoring network for coastal waters and tributaries is to have clear goals, to specify variables, and to be periodically reviewed and updated. NOAA, USGS, and EPA, at the request of the Advisory

Committee on Water Information, issued a network design in April 2006. In 2008, three pilots of the network design were completed. One of those pilots was the Lake Michigan Pilot. It compared the probabilistic design for the Great Lakes to existing monitoring programs in Lake Michigan. The NMN Great Lakes design is being used to plan the 2010 Great Lakes Basin monitoring for a National coastal conditions report. The 2010 monitoring will be the first time coastal monitoring has been completed in the Great Lakes as part of the U.S. EPA National coastal conditions report. This abstract represents the views of the author and does not necessarily represent the official position of U.S. EPA. *Keywords: Monitoring, Water quality, Coasts.*

BRECKENRIDGE, A.J.¹, LOWELL, T.V.², FISHER, T.G.³, and YU, S.Y.⁴, ¹Mercyhurst College, Department of Geology, 501 E. 38th St., Erie, PA, 16546; ²Department of Geology, University of Cincinnati, Cincinnati, OH, 45221; ³Department of Earth, Ecological, and Environmental Science, The University of Toledo, Toledo, OH, 43606; ⁴Department of Earth and Environmental Sciences, Tulane University, New Orleans, LA, 70118. **A 9,500 cal BP Rapid Lake Level Rise During the Lake Minong Phase of Lake Superior as Evidenced by Sediments from Fenton Lake, Ontario.**

Previous lake level reconstructions for Glacial Lake Minong (Lake Superior basin) between the Minong I highstand to the Houghton level lowstand need to be modified. Fenton Lake (near Wawa, ON) was a former embayment of Lake Minong, and this record and others were used to demonstrate falling water levels from 10,600 to 9,000 cal BP due to sill incision of the St. Mary's River outlet and isostatic rebound (Saarnisto, 1975). Over three meters of previously unrecovered sediment from Fenton Lake detail a cycle of a regression, transgression, and a final regression. Only the final regression was documented by Saarnisto (1975). The transgression was abrupt and dated to around 9,500 cal BP. The event may be the result of catastrophic flooding of the Superior basin from Glacial Lake Agassiz. In light of both this undocumented transgression, and a much older transition to lower lake levels than previously reported, our current understanding of Lake Minong lake levels is reassessed. *Keywords: Lake Superior, Lake Agassiz, Sediments.*

BROWN, J.E.¹, STEWART, K.M.², GRIGOROVICH, I.³, and STEPIEN, C.A.¹, ¹Lake Erie Center, University of Toledo, Toledo, OH, 43618; ²Department of Biological Sciences, State University of New York - Buffalo, Buffalo, NY, 14260; ³Wilson Environmental Labs, Inc., 6201 Congdon Blvd., Duluth, MN, 55804. **Population Genetic History of the Dreissenid Mussel Invasion and Expansion across North America.**

The dreissenid mussel invasion continues to threaten North American waterways; expanding from the Great Lakes, zebra and quagga mussels have colonized the Mississippi River basin, Atlantic coastal waterways, the Colorado River system, and California reservoirs. We test source-spread relationships and invasion genetics using mtDNA cytochrome b sequences and 11-12 new nuclear microsatellite loci for ~500 individuals per species from 15-20 Eurasian and North American locations. MtDNA confirms species identity, and both species display significant genetic structure with microsatellite data. Great Lakes zebra mussel populations show

temporal genetic shifts, changing over the invasion's course. Western populations in Kansas and California appear genetically more similar to each other than to lower Great Lakes populations. North American zebra mussels appear linked to northern Europe sources, rather than the Black Sea. We confirm that quagga mussels have colonized Oneida Lake and continue to expand along waterways connected to the Great Lakes. Quagga mussel colonizations in Nevada and California show evidence of founder effects and significantly differ from likely Great Lakes sources.

Keywords: Genetics, Exotic species, Dreissena.

BROWN, L.¹, TALEBAN, V.¹, GHARABAGHI, B.¹, WINTER, J.², and WALTERS, M.³,
¹School of Engineering, University of Guelph, Guelph, ON, N1G 2W1, Canada; ²Ontario Ministry of the Environment, 125 Resources Road, Toronto, ON, M9P 3V6, Canada; ³Lake Simcoe Region Conservation Authority, 120 Bayview Parkway, Newmarket, ON, L3Y 4X1, Canada. **Atmospheric Deposition of Phosphorus to Lake Simcoe.**

A decline in the water quality of Lake Simcoe has been observed over the past few decades. This decline has been attributed to excessive phosphorus load causing eutrophication of aquatic ecosystems. It has been estimated that 25-35% of the total phosphorus entering the lake is via atmospheric deposition. Airborne dust and associated nutrients are returned to the ground or the lake surface by wet (event based) or dry (continual) deposition processes. The main objective of this study was to estimate the temporal and spatial variability of bulk atmospheric phosphorus deposition over Lake Simcoe. The time period of interest was 2004 -2007 and three data sets were used in this study, radar precipitation data, rain gauge data, and total phosphorus (TP) deposition from bulk collectors positioned within the study area. The approach used in this study utilizes GIS functionalities and remotely sensed precipitation patterns over the lake to spatially distribute phosphorus deposition. Temporally TP deposition peaks during the late spring and summer months. Future studies will apportion likely sources of dust emission and associated phosphorus corresponding to the key sources. *Keywords: Lake Simcoe, Phosphorus, Remote sensing.*

BURLAKOVA, L.E.¹, KARATAYEV, A.Y.¹, BOLTOVSKOY, D.², KARATAYEV, V.A.³, CATALDO, D.², and SYLVESTER, F.⁴, ¹Great Lakes Center, Buffalo State College, 1300 Elmwood Avenue, Buffalo, NY, 14222, USA; ²Department of Biological Sciences, School of Exact and Natural Sciences, University of Buenos Aires, C1428eha 1428, Buenos Aires, Argentina; ³City Honors School, 186 East North Street, Buffalo, NY, 14204, USA; ⁴Great Lakes Institute for Environmental Research, University of Windsor, 401 Sunset Ave., Windsor, ON, N9B 3P4, Canada. ***Limnoperna fortunei*: The New Potential Invader to the Great Lakes.**

The mytilid *Limnoperna fortunei*, native to Southeast Asia, recently invaded South America, causing significant ecological and economic impacts. In the near future, this mollusc is very likely to invade North America. *Limnoperna* is a suspension feeder and much of its ecosystem effects are due to shifting energy and matter from the water column to benthic communities. While the magnitude of these impacts depends on the population size, data on its abundance over large areas are virtually absent. We studied *Limnoperna* population density and distribution, the effect of its aggregations on benthic communities, and its ecosystem-wide

impacts in Río Tercero Reservoir (Argentina). We found that the impacts on benthic invertebrates and the ecosystem-wide effects were comparable to those described for *Dreissena polymorpha*. However, *Limnoperna* attains higher biomass values, and may therefore have stronger impacts on the invaded ecosystems. *Limnoperna* has broader environmental tolerance to high temperatures, low pH, low calcium content, oxygen depletion and water pollution than *D. polymorpha*, and may be more successful in acidic, soft and contaminated waters. *Limnoperna* may be more aggressive invader than *Dreissena* in North America with stronger environmental impacts. *Keywords: Invasive species, Density, Benthos, Effect on ecosystems, Mussels.*

BUSHKIN, S.C. and CARPENTER, D.O., University at Albany, One University Place, Rensselaer, NY, 12144. **Health Effects of Omega 3 Fatty Acids.**

For many years, there has been increasing enthusiasm for the dietary use of omega 3 fatty acids because of their perceived benefits. Among many of these benefits are: 1. cardioprotective function 2. anti-inflammatory effects 3. ability to suppress tumor growth 4. ability to support fetal development resulting in higher birth weights and more well developed central nervous system. 5. Ability to lower lipid levels 6. beneficial function for diabetics 7. treatment of schizophrenia, autism, ADHD, dementia The literature contains many articles describing these effects, among others. However, the medical literature also includes many reports which reveal opposing results. The purpose of this paper is to explore and analyze the beneficial effects as well as the possible risks of omega 3 fatty acids in human health. *Keywords: Chemical analysis, Environmental health, Fish.*

BUTTERWORTH, F.M.¹, JANECEK, K.², WOLFE, E.³, and SIMOLIUNAS, S.¹, ¹Institute for River Research International, Prescott Valley, AZ, 86314; ²Citizens Water Advisory Group, Prescott, AZ, 86305; ³Verde Watershed Association, Prescott, AZ, 86305. **Aquifer Recharge by Treated Wastewater: an Emerging Crisis.**

There is an emerging crisis of water pollution by tens of thousands of anthropogenic chemicals that escape standard wastewater treatment. This crisis is nationwide, including sensitive areas such as the Great Lakes. But because the rapidly growing arid Southwest uses such effluent to recharge its depleting aquifers, there is an acute need now for a better understanding of this problem and a more complete treatment process to protect human and environmental health. Important among these contaminants is a broad suite of endocrine-disrupting compounds (EDCs) that include natural or synthetic hormones as well as chemicals that mimic hormones and may interfere with the operation of endocrine systems of aquatic animals or humans even at concentrations of part per trillion. Indeed, a growing body of evidence suggests that some aquatic organisms are adversely affected at these levels where treated wastewater is discharged into streams. The presentation will elaborate on these points to build a case that this issue deserves attention, and will attempt to outline a logical sequence of questions that should be addressed. *Keywords: Endocrine disruption, Environmental contaminants, Human health.*

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

CABRERA, S.C.¹, BOEHME, S.E.², HINCHEY MALLOY, E.K.², ADAMS, J.M.², and SMITH, E.R.³, ¹Oak Ridge Institute for Science and Education, 77 West Jackson Blvd. G-17J, Chicago, IL, 60604; ²Illinois Indiana Sea Grant, 77 West Jackson Blvd. G-17J, Chicago, IL, 60604; ³U.S. EPA Great Lakes National Program Office, 77 West Jackson Blvd. G-17J, Chicago, IL, 60604.

Disposal of Unwanted Medicines: A Resource for Action in your Community.

Pharmaceuticals are produced in increasing volumes every year. With this growth comes concern regarding the environmental fate of these compounds. Recent studies identified pharmaceuticals in fresh and marine waters nationwide, as well as several bioactive compounds that are potentially harmful to aquatic organisms, even in small quantities. 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, be flushed, placed in the trash, or given to others; all having significant disadvantages. One approach for decreasing the amount of unwanted medicines reaching the environment is through collection programs that ensure safer methods of disposal. We highlight the Illinois-Indiana Sea Grant toolkit “Disposal of Unwanted Medicines: A Resource for Action in Your Community.” The toolkit focuses on collection events for the public as a partial solution to the problem. The toolkit provides: case studies, sample educational materials, advice for running a collection, and information on the science behind the issue including a bibliography of news stories and scientific articles. Since it has been utilized widely, several examples from EPA’s 1 million pill Earth Day Challenge will be highlighted.

Keywords: Outreach, Pharmaceuticals, Pollution prevention.

CAMPBELL, L.M., Department of Biology & School of Environmental Studies, Queen's University, Kingston, ON, K7L 3N6. **Non-Indigenous Species and Contaminant Transfer.**

Will edit abstract before Feb 20. *Keywords: Biomagnification, Food chains, Great Lakes basin.*

CAMPBELL, M.¹, FISHER, T.G.¹, MARTIN-HAYDEN, J.¹, and GOBLE, R.J.², ¹Dept. Environmental Sciences, University of Toledo, Toledo, OH, 43606; ²Department of Geosciences, University of Nebraska-Lincoln, Lincoln, NE, 68588. **The Evolution of the Lake Warren Coastline in the Oak Openings Region in Northwest Ohio, USA.**

During recession of the Huron-Erie lobe at the end of the last ice age, lacustrine and littoral sediment was deposited in ice-contact proglacial lakes in the Lake Erie basin. The Oak Openings Region (OOR) is a broad beach ridge or series of ridges associated with glacial Lake Warren with superimposed parabolic and complex dunes fields. The objective of this study is to determine if the OOR represents one, or a series of lake levels of Lake Warren, and to determine absolute dates for the OOR. From a LiDAR-based DEM we identified geomorphic signatures of a regional paleocoastal setting. Guided by the DEM to focus our surveys, we used ground penetrating radar to explore dune and coastal landforms to distinguish between eolian and littoral structures, and to map the 0–16 m thick sand across the region. Sedimentary structures exposed in a sand pit within the thickest part of the OOR ridge are characteristic of a littoral environment, indicating that the core of the OOR is a shoreline deposit. OSL dates between 12 and 13 cal ka

show concurrent ages for several sand dunes in the OOR; younger than the assumed shoreline age of 15,000 cal ka. Additional OSL samples being processed from sand dunes and beaches associated with earlier stages of the glacial lake will test whether the sand dunes are contemporaneous with beach formation. *Keywords: Climates, Coastal processes, Lake Erie.*

CARREON-MARTINEZ, L.B.¹, HEATH, D.D.¹, LUDSIN, S.A.², and JOHNSON, T.³, ¹Great Lakes Institute for Environmental Research, University of Windsor, 401 Sunset Ave, Windsor, ON, N9B3P4; ²The Ohio State University, 1314 Kinnear Rd., 232 Research Center, Aquatic Ecology Laboratory, Columbus, OH, 43212; ³Ontario Ministry of Natural Resources, Glenora Fisheries Station R.R. #4, 41 Hatchery Lane, Picton, ON, K0K 2T0. **Yellow Perch (*Perca flavescens*) Larval Survival in the Western Basin of Lake Erie Estimated using Genetic Analysis.**

Yellow perch (*Perca flavescens*) (YP) is an economically important species for the Great Lakes, yet we do not yet understand variation in recruitment. Predation of YP larvae may represent a significant limitation in first year survival of YP since the western basin of Lake Erie is an important rearing habitat for YP. The western basin of Lake Erie receives input from two main tributaries (Maumee and Detroit River), that differ greatly in their nutrient and sediment loading. Turbidity and nutrient levels are elevated in the Maumee River plume, and YP recruitment is correlated with Maumee River discharge. The objective of this project is to use population genetic analyses to estimate YP larval survival in the Maumee and Detroit River plumes. We genotype larval and age 0+ YP from the western basin of Lake Erie at 8 microsatellite DNA loci over multiple years. We use those data to; 1) determine genetic divergence between larvae from the two plumes, 2) genetically assign age 0+ juveniles to their original larval plume habitat, and 3) test for a genetic signature of effective population size changes in the two plumes. Based on abundance estimates of the larvae in each plume, coupled with the source determination for the juvenile YP, we will estimate first-year survival for the YP from the two larval nursery areas. *Keywords: Genetics, Yellow perch, Lake Erie.*

CARRICK, H.J.¹, RIPPLE, S.¹, JUNGBLUTH, L.¹, NALEPA, T.F.², and HAWLEY, N.², ¹School of Forest Resources, Penn State University, University Park, PA, 16802, USA; ²Great Lakes Environmental Res. Lab., National Oceanic & Atmospheric Admin., Ann Arbor, MI, 48108, USA. **Is There a Link Between Seasonal Phytoplankton Dynamics and Hypoxia in Lake Erie?**

The occurrence of hypoxia in coastal zones of throughout the world is growing at an alarming rate. Hypoxia in lakes and coastal zones is usually tied to imbalances in the rate of production versus oxidation of organic matter. In this paper, we test the hypothesis that the phytoplankton spring bloom in Lake Erie is a significant source of carbon that contributes to hypoxia in the central basin. Our approach relied on a series of complimentary data strings (bottle experiments, in situ sediment traps) that were used to calculate a carbon mass balance at representative sites in the basin. Bottle enclosure experiments provided simultaneous rate measurements of phytoplankton growth and grazing losses attributable to micro- and mesozooplankton (May-Oct 2005). These rates were balanced against sedimentation losses

derived from in traps that were deployed in situ throughout the year in 2005. This material mass balance was calibrated against oxidation of organic matter in the benthos. Our findings indicate that large phytoplankton (diatoms and cryptophytes) were ungrazed in the May-June period and can account for ~50% of benthic oxidation. Tight coupling between smaller phytoplankton and grazers was observed throughout most of the year and had little effect on hypoxia.

Keywords: Diatoms, Mass balance, Carbon cycle.

CASTANEDA, M.¹, FISHER, T.G.¹, LOOPE, W.L.², and GOBLE, R.J.³, ¹Dept. Environmental Sciences, University of Toledo, Toledo, OH, 43606; ²U.S. Geological Survey, N8391 Sand Point Rd, P.O. Box 40, Munising, MI, 49862; ³Department of Geosciences, University of Nebraska-Lincoln, Lincoln, NE, 68512. **Determining the Age for the Sand Point Cuspate Foreland, Pictured Rocks National Lakeshore, Michigan, USA.**

Sand Point is a small cusped foreland located in the lee of Grand Island along the eastern edge of Pictured Rocks National Lakeshore. Sand Point is an amalgamation of beach ridges recording littoral transport from a variety of directions indicating that it is a composite feature wherein beach-ridge growth and spit formation alternated with erosional events. Sediment building the foreland is sourced from the adjacent weakly cemented Cambrian-aged sandstone cliffs. Three ponds in the middle of the foreland are ~600 years old as determined by basal radiocarbon dates from cores. Preliminary OSL ages from beach ridges across the foreland, though possibly hindered by partial bleaching, similarly indicate that the foreland is at most a few thousand years old. Moreover, the low relief and elevation of this landform is consistent with beach ridge sequences observed elsewhere in the Superior basin assigned a maximum age of ~1200 years. We conclude that Sand Point is a young, composite landform, likely sensitive to lake level fluctuations. *Keywords: Water level, Coastal processes, Lake Superior.*

CAVALETTO, J.F.¹ and POTHOVEN, S.A.², ¹NOAA/ Great Lakes Environmental Research Lab, 4840 S. State Rd., Ann Arbor, MI, 48108; ²NOAA/ Lake Michigan Field Station, 1431 Beach St., Muskegon, MI, 49441. **Seasonal Patterns of Zooplankton from a Southern Lake Huron Transect in 2007.**

As a part of EPA's year of Lake Huron 2007, we monitored changes in zooplankton from April through October at sites in transect from near shore at 18-m-deep to off shore at 102-m-deep off Harbor Beach, Michigan. Calanoid copepods were the most abundant group of zooplankton and they consisted of over 50% and as much as 90% of total zooplankton during most months. Diaptomid copepodites were most abundant, with *Leptodiaptomus sicilis* and *L. minutus* the most frequently found species. Cyclopoid copepods reached a high of 30% of total zooplankton at off shore sites in July. Cladocerans (*Bosmina* and *Daphnia* combined) reached a maximum of 26% of total zooplankton in October at one site. *Dreissena* veligers were most abundant at 18-m-deep and 37-m-deep sites at a maximum of 17% of zooplankton. Total biomass averaged around 10 mg m⁻³ in April and 20 mg m⁻³ during the summer months. However, in October total biomass increased to 70, 39 and 32 mg m⁻³ at near, mid and off shore sites, respectively. Contributors to the biomass increase in late October were adult *L. sicilis* and

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

Daphnia mendotae. The predatory cladoceran, *Bythotrephes longimanus* also increased off shore during October. *Keywords: Lake Huron, Biomonitoring, Zooplankton.*

CHAFFIN, J.D., BRIDGEMAN, T.B., and HECKATHORN, S.A., Dept. of Environmental Sciences and Lake Erie Center, University of Toledo, Toledo, OH, 43606. **The Effects of Light and Mixing on Photosynthesis Physiology of *Microcystis* in Western Lake Erie.**

Microcystis is generally predicted to have an ecological advantage over non-buoyant phytoplankton in calm turbid waters because buoyancy regulation allows access to more light and surface scums further shade non-buoyant phytoplankton. However, exposure to full sunlight may have negative effects on *Microcystis* physiology. Field sampling of the 2008 bloom in western Lake Erie and laboratory experiments were used to study the physiological status of *Microcystis* in relation to turbidity, vertical mixing, and nutrients. Photosynthetic efficiency of *Microcystis* (quantum yield of electron transport of photosystem II) (Φ) was measured throughout the summer. Φ was greatest under vertical mixing conditions and lower in calm waters. Under both mixing and calm conditions, Φ increased with turbidity at all depths. Because turbidity often co-varies with nutrients in Lake Erie, laboratory experiments were used to separate the effects of turbidity and nutrients (P, N). Φ was highest in the mixed turbid treatment and lowest in the calm clear treatment. Nutrient concentrations normal to western Lake Erie did not affect Φ . Thus, an eco-physiological trade-off exists between being highly competitive for light and decreased photosynthetic efficiency in calm turbid waters. *Keywords: Microcystis, Photosynthesis, Lake Erie.*

CHAPMAN, K., Environmental Defense Fund, 223 North Union Street, Delaware, OH, 43015. **Conservation Incentives in the Maumee Watershed.**

Environmental Defense's Center for Conservation Incentives aims to improve Lake Erie water quality by significantly reducing Maumee watershed agricultural runoff. The project enlists farmers, state and federal agencies, for-profit entities and non-profit groups as partners, and encompasses northwestern Ohio, eastern Indiana and southern Michigan. The WLEB project utilizes tools like the Lake Erie Conservation Reserve Enhancement Program (CREP) – a USDA program administered by the Farm Services Agency, and the Environmental Quality Incentives Program (EQIP) which provides financial and technical assistance to farmers for implementing conservation practices in the field. Through CREP, farmers volunteering to help improve water quality by taking ecologically sensitive land along rivers and streams out of production and planting them to grass and tree buffers can get financial and technical help. Key to program delivery are the on-the-ground experts under contract with EDF – soil and water supervisors, retired NRCS employees, and Certified Crop Advisors – who have instant credibility with farmers and understand the ins and outs of these sometimes complex programs. For maximum participation and ecological benefits, the project team is focusing much of its effort on the Tiffin and the Blanchard watersheds in Ohio. *Keywords: Watersheds, Ecosystems, Management.*

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

CHAPRA, S.C.¹, DOVE, A.², and WARREN, G.J.³, ¹Civil and Environmental Engineering, Tufts University, Medford, MA, 2155; ²Water Quality Monitoring and Surveillance, Environment Canada, Burlington, ON, L7R 4A6; ³US EPA Great Lakes National Program Office, 77 W. Jackson Blvd., Chicago, IL, 60604. **Long-Term Trends in the Major-Ion Chemistry of the Lower Great Lakes.**

Data collected over the past 150 years are compiled and analyzed to identify trends in the major-ion chemistry of Lakes Erie and Ontario. Time series are developed for the major cations (calcium, magnesium, sodium, potassium) and anions (chloride, sulfate, bicarbonate, carbonate, and nitrate). Trends are also generated for a number of aggregate variables (TDS, hardness, specific conductance, alkalinity, and ionic strength). After rising during the early twentieth century, chloride, sodium, calcium, and sulfate concentrations began decreasing during the 1970's. Minimum levels were reached in the 1990s, but concentrations of chloride and sodium now appear to be rising again. Although the data for sulfate also suggest a similar pattern of significant decline followed by recent rise, the trend is less evident, possibly due to the impact of acid-rain on this ion. In contrast, the data for calcium show a recent decline, hypothesized to be due to the impacts of zebra mussels and calcite precipitation. *Keywords: Dissolved solids, Lake Erie, Lake Ontario.*

CHAPRA, S.C.¹ and DOLAN, D.M.², ¹Tufts University, Civil and Environmental Engineering, Medford, MA, 2155; ²University of Wisconsin - Green Bay, Natural and Applied Sciences, Green Bay, WI, 54311. **Updating Great Lakes Total Phosphorus Mass Balances.**

A combination of modeling and data analysis is employed to evaluate whether target loads for total phosphorus established by the Great Lakes Water Quality Agreement (GLWQA) have been and are currently being met. 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 Michigan and Huron for 2008-2009. A mass balance model is used to compare projections with direct estimates from measurements obtained primarily from the mid-1970s to the present. The analysis suggests that the target load has been consistently met for the main bodies of Lakes Michigan and Huron. However, exceedences still persist for Green and Saginaw Bays and many other smaller embayments. *Keywords: Phosphorus, Mathematical models, Lake Huron.*

CHENG, S.T. and WILEY, M.J., School of Natural Resources & Environment, University of Michigan, 440 E. Church Street, Ann Arbor, MI, 48109. **Predicting the Thermal Impacts on Hypothetical Dam Removals in the Muskegon River.**

The Muskegon River is one of the places provided high quality nursery habitats for steelhead (*Oncorhynchus mykiss*). However, three major hydropower dams located on the middle main stem of the river without having fish passage, making the potential spawning and nursery habitats upstream not accessible. Moreover, much has been known about changes in stream temperature accompanied the operation of the dams, which potentially reduce the suitable thermal habitats for steelhead. The objectives of this study were to determine whether removing

the dams would alter the Muskegon River thermal regime and, consequently, cause shifts in the timing of steelhead spawning activities. A newly constructed Reduced Parameter Stream Temperature Model (RPSTM) coupled with the hydrological models was applied to estimate stream temperature under "with dams" and "dams removed" scenarios at the lower mainstem of the Muskegon River from 1996 to 2005. Following dam removals would lower stream temperature for sites right at or below dams all year round. Taking only thermal effects into account, dam removals would cause delays in the timing of steelhead spawning activities. This will be important information allowing fishery management agencies to plan their stocking strategies more successfully. *Keywords: Dam removal, Salmon, Steelhead, Ecosystems.*

CHOC, S.J., WALTZ, A.R., and DWYER, D.F., The University of Toledo, Lake Erie Center, 6200 Bayshore Rd., Oregon, OH, 43618. **Water Quality Trends and Models for the Design of Wetlands Used to Treat Drainage Water Entering Lake Erie.**

The drainage water of Berger Ditch contributes *Escherichia coli*, sediment and nutrients to the near-shore region of Lake Erie at Maumee Bay State Park in Oregon, OH. Constructed wetlands are proposed to intercept and improve the drainage water prior to entering Lake Erie. Design considerations require monitoring profiles that include low- and high-flow periods of time and basic water quality parameters. A monitoring station, equipped with an acoustic Doppler velocity meter and automatic water sampler, was used to collect data on discharge volumes, densities of *E.coli*, total suspended solids (TSS) and total phosphorus (TP) near the outflow of Berger Ditch. Samples collected between 7/27/07 and 8/21/08 were analyzed for *E.coli* (n=1288) and TSS (n=1161). TP was analyzed during summer 2008 (n=158). Overall, low-flow and low-pollutant levels predominated; intermittent storm events contributed the majority of pollutant mass. Time series and correlations indicate that these water parameters trend together during storm events, with distinct seasonal differences. However, the influence of seiche and other watershed variables reduces these trends during low-flow periods. Results will be presented with discussion of hydrologic and hydraulic models that were developed to aid in wetland design. *Keywords: Lake Erie, Microbiological studies, Sediment transport.*

CHOI, H.D.¹, HOLSEN, T.M.¹, MILLIGAN, M.S.², HOPKE, P.K.³, and PAGANO, J.J.⁴, ¹8 Clarkson Ave., Department of Civil and Environmental Engineering, Clarkson University, Potsdam, NY, 13699, United States; ²218 Houghton Hall, 280 Central Ave., Department of Chemistry, SUNY Fredonia, Fredonia, NY, 14063, United States; ³8 Clarkson Ave., Center for Air Resources Engineering and Science, Clarkson University, Potsdam, NY, 13699, United States; ⁴310D Piez Hall, Takamin St., Department of Chemistry, SUNY Oswego, Oswego, NY, 13126, United States. **Polychlorinated Biphenyls (PCB) Air Concentrations in the Lake Ontario Region: Trends and Potential Sources.**

The average concentration (\pm standard deviations) of airborne PCBs was 610 ± 781 pg m⁻³ at Oswego, NY between April 2002 and June 2006 (number of samples: n=138). Yearly average PCB concentrations were low in 2002 (373 pg m⁻³) and 2003 (233 pg m⁻³), peaked in 2004 (1633 pg m⁻³) and decreased again in 2005 (686 pg m⁻³) and 2006 (190 pg m⁻³). Clausius-Clapeyron (C-C) regression analysis of these data yielded a good correlation ($r^2 = 0.56$, $p <$

0.001) and the slope was similar to that found by other researchers suggesting that concentrations at this site are influenced by volatilization of PCBs from the earth's surface. More than half of the measured PCB partial pressures in 2004 were above the 95% confidence interval of the C-C regression of all of the data (approx. 0.44 atm higher than those in other sampling years). The results from meteorological analysis indicated that these unusual concentrations occurred when there was no precipitation; the wind direction was from southwest where significant sources are located; and the transport speed was slow. These conditions occurred significantly more often in 2004 than during the other years. Potential Source Contribution Function Modeling identified urban areas as significant PCB sources. *Keywords: PCBs, PSCF.*

CHOLGER-BLUST, S.¹, SCHLOESSER, D.W.², HAAS, R.C.³, and HUNTER, D.¹, ¹Oakland University, Rochester, MI, 48039-4401; ²USGS, Great Lakes Science Center, Ann Arbor, MI, 48105; ³Michigan DNR, Lake St. Clair Fisheries Station, Harrison Township, MI, 48045.

Submersed Aquatic Macrophytes in Lake St. Clair between Lakes Huron and Erie; 1995 and 2007 with Comparison to Baseline Data of 1978.

In 1994, excessive macrophyte growth impacted recreational activities (e.g., swimming) in Lake St. Clair. In the present study, we surveyed macrophytes in Lake St. Clair to determine changes between 1995 and 2007. In addition, we compared these data to similar data collected in 1978, a period typical of growth between the 1960s and 1980s. Between 1995 and 2007, few differences occurred in species distribution, composition, and abundance. Notable exceptions include decreased occurrence of *Elodea canadensis*, *Myriophyllum spicatum*, and *Nitella spp.*, and decreased biomass of total vegetation. However, data of 1995-2007 contrast to data of 1978. For example, in 1978, 52% of sites had no vegetation compared to 8-10% of sites in 1995-2007 and occurrence of *Elodea*, a major contributor to problematic growth in 1994, increased from 19% in 1978 to 56-37% of sites in 1995-2007. In addition, occurrence of *Vallisneria americana*, a primary food of waterfowl, increased between 1978, 1995, and 2007 (34 to 66 to 75 sites) but declined in biomass from 44 to 10 to 9% over the same comparison. Although, major changes of macrophytes occurred between 1978 and 1995-2007, stability between 1995 and 2007 indicates future changes in macrophytes are unlikely unless a fundamental change occurs in the ecosystem of Lake the St. Clair. *Keywords: Lake St. Clair, Submerged plants, Monitoring.*

CIBOROWSKI, J.J.¹, BARKER, N.¹, and SHERMAN, R.K.², ¹Department of Biological Sciences, University of Windsor, Windsor, ON, N9B 3P4; ²Severn Sound Environmental Association, 67 Fourth St, Midland, ON, L4R 3S9. **Benthic Invertebrate Community Composition in Severn Sound, (Georgian Bay) Lake Huron – 2007/08.**

Severn Sound was designated an Area of Concern largely because nutrient enrichment caused poor water quality and degraded ecosystem health (including zoobenthos). Benthic community composition indicated that waters of Severn Sound were in a state of recovery following remediation measures that improved water quality in the 1990s. To determine whether these changes have persisted Ponar grab samples were collected at 25 locations (corresponding to areas previously sampled in 1994 and 1998) in Midland Bay, Penetang Bay and adjacent open

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

waters in April & August 2007 and in August 2008. In 1998, 1994, 34 *Hexagenia* larvae/m² were found, at 68% of sites sampled. Cluster analysis identified 3 distinctive groups of sites based on relative community composition. Shallow water (<4 m deep) sites near shorelines were dominated by crustaceans (*Asellus* and *Gammarus*) and *Dicrotendipes* chironomids. A second group of sites characterized by sphaeriid molluscs, *Tanytarsini* chironomids, nauidid worms, and *Hexagenia* mayflies occupied deeper parts of Midland and Penetang bays. *Hexagenia*, *Chaoborus*, and tubificid worms distinguished the deepest sites, characteristic of open waters. In 2007/8, densities of many taxa, including *Hexagenia* were considerably lower than in 1998, although community composition was similar. *Keywords: Benthos, Georgian Bay, Eutrophication.*

CLARAMUNT, R.M., MDNR - Charlevoix Fisheries Research, 96 Grant Street, Charlevoix, MI, 49720. **Evidence of a Remnant Cisco Stock in Grand Traverse Bay, Lake Michigan.**

Cisco (*Coregonus artedi*, formerly called lake herring) was historically one of the most important commercial fish species in the Great Lakes. In Lake Michigan, cisco populations were an integral component of the fish community and were a primary diet item for native lake trout piscivores. Invasive species introductions and overfishing have been identified as the primary causes of the cisco declines up to the 1960s and currently only Lake Superior supports an abundant cisco population. The objective of this study was to evaluate evidence of a remnant cisco spawning stock in Grand Traverse Bay, Lake Michigan. Adults were sampled using acoustics, midwater trawls, and gill nets during their potential spawning period (October – December). Adult cisco in spawning condition were collected mainly in weekly gill nets that were set on shallow, rocky spawning habitat. Eggs and emergent fry were also captured, indicating that adult cisco are reproducing successfully. Additional work is needed to evaluate if this remnant cisco population is increasing and if there is potential for expansion into the main lake. *Keywords: Cisco, Lake Michigan, Recruitment.*

CLEMENS, L., The Nature Conservancy, 1505 N. Delaware St. #200, Indianapolis, IN, 46202. **Hydrology and Restoring Wetlands and Floodplain Forests: Improving Water Quality and Protecting Biodiversity in the Western Lake Erie Watershed by Naturalizing.**

The four projects of The Nature Conservancy funded by the Joyce Foundation are focused on showing how targeting public and private resources can help improve the Maumee River watershed water quality and quantity challenges. The projects that will be described after two years of implementation include: install five to ten miles of a two-stage ditch demonstration project (Fish Creek), and improve water quality by reducing sediment by 20%, phosphorus loadings by 20%, and nitrogen loadings by 20%, while measurably slowing runoff to measurable levels within three years; restore 1,500 acres of wetlands and riparian corridors along the St. Joseph River and its tributaries to filter water for nutrients and chemicals and to reduce soil erosion; facilitate the growth of a grass roots partnership to protect a 130 square mile region of northwest Ohio (Green Ribbon Initiative); restore 100 acres of unique remnant wetlands, savanna, and prairie habitat in northwest Ohio in the Oak Openings region; develop a tool kit for watershed managers and drainage officials applicable throughout the Great Lakes basin; and

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

leverage at least \$1.5 million in federal and state program funding. *Keywords: Watersheds, Ecosystems, Management.*

CLEVINGER, C.C., BADE, D.L., and HEATH, R.T., Department of Biological Sciences, Kent State University, PO Box 5190, Kent, OH, 44242-0001. **Potential Impacts of Nitrification on the Formation of Hypoxia in Lake Erie.**

After the disappearance of hypoxia for many years, large regions of hypoxia are again present in Lake Erie's Central Basin during summer stratification without a definitive reason for its recurrence. In freshwater ecosystems, oxygen depletion caused by nitrification has received limited attention, and information about nitrification and the formation of hypoxia in Lake Erie is even more sparse. Nitrification is the bacterially mediated chemoautotrophic process of ammonium oxidation to nitrate that consumes 2 moles of oxygen per mole of ammonium oxidized. Sampling of sediments and the water column was performed during the summer of 2008 at 4 Central Basin sites to evaluate the contribution of nitrification to oxygen depletion. Both amended and unamended potential oxygen demand due to nitrification were measured in BOD bottles by comparing oxygen consumption in inhibited vs. uninhibited bottles. Preliminary data showed that nitrification in the water column and sediments accounted for 5-80% of the total oxygen consumption. Addition of ammonium had little effect on the nitrification rate or extent. These findings on the contribution of nitrification to total oxygen consumption suggest the need to expand the search for causes of hypoxia beyond the traditional view of eutrophication via excessive P loading. *Keywords: Nutrients, Biogeochemistry, Oxygen.*

COLE, P.¹ and BODAMER, B.L.², ¹Toledo Early College High School, 2225 Nebraska Avenue, Toledo, OH, 43607; ²Department of Environmental Sciences, The University of Toledo, Toledo, OH, 43606. **Introducing High School students to Environmental Monitoring: a Look at Water Quality in the Ottawa River.**

As part of the Student Watershed Watch, a program by the Toledo Metropolitan Area Council of Governments (TMACOG) and the NSF GK-12 program, our freshman/sophomore biology class measured water quality parameters to assess a stretch of the Ottawa River near Jermain Park, Toledo, Ohio. Our class collected data at one site and compared the water quality parameters at our site with those upstream that were monitored by other classes in the Student Watershed Watch. Measurements included temperature (12 °C), dissolved oxygen (6 mg/L), pH (8.5), phosphorus (0.133 mgPO₄/L), nitrite (0.44 mg/L), fecal coliform (191 cfu/ml), and total suspended solids (22.76 mg/L). Our site had lower temperatures, less total solids, and lower nitrite concentrations than the upstream sites. Alternatively, our site also had significantly higher fecal coliform and elevated pH. All other measurement were comparable between sites, including benthic invertebrate community composition, which was poor for this stretch of river. Overall, the water quality was similar to the upstream sites and we recorded a cumulative water quality metric of "medium" for this stretch of the Ottawa River. *Keywords: Monitoring, Water quality, Education.*

COLLINGSWORTH, P.D. and MARSCHALL, E.A., 1314 Kinnear Road, Columbus, OH, 43212. **Spatial Differences in Lake Erie Female Yellow Perch Growth, Survival, and Energetic Condition: Consequences for Estimates of Lake-Wide Total Egg Production.**

Because previous studies have documented a positive relationship between maternal traits and the quality or quantity of eggs, understanding stock-recruitment relationships requires stock-specific knowledge of maternal traits. In the present study, female yellow perch reproductive and demographic traits were measured over three spawning seasons in the western and central basins of Lake Erie. Overall, we detected a positive relationship between female mass and the energy content of her somatic tissues and ovaries. This suggests that larger females produce higher quality eggs than smaller females. We then used basin-specific demographic data collected during the study to develop a deterministic egg production model for yellow perch populations residing in the western and central basins of Lake Erie. The results from our egg production model suggest that, due to basin-specific differences in growth and mortality rates, females in the central basin produce more eggs than those in the western basin and a higher proportion of eggs in the central basin are produced by older, larger females. Our results illustrate the potential for variability in basin-specific measures of total egg production and could be used to further improve stock-recruitment models for yellow perch in Lake Erie. *Keywords: Lake Erie, Yellow perch, Percids.*

CONROY, J.D.¹, LUDSIN, S.A.¹, KAYLE, K.², TYSON, J.T.³, KNIGHT, R.L.³, COOK, H.A.⁴, and CULVER, D.A.⁵, ¹Aquatic Ecology Laboratory, The Ohio State University, 1314 Kinnear Road, Columbus, OH, 43212; ²Ohio Department of Natural Resources, Division of Wildlife, Fairport Fisheries Research Unit, 1190 High Street, Fairport Harbor, OH, 44077; ³Ohio Department of Natural Resources, Division of Wildlife, Sandusky Fisheries Research Unit, 305 East Shoreline Drive, Sandusky, OH, 44870; ⁴Ontario Ministry of Natural Resources, Lake Erie Management Unit, 320 Milo Road, R.R. # 2, Wheatley, ON, N0P 2P0; ⁵Limnology Laboratory, The Ohio State University, 1315 Kinnear Road, Columbus, OH, 43212. **Fish Community Structure in Lake Erie: Continued Rehabilitation or a Return to Degradation?**

During the last 30 years Lake Erie has undergone many changes in terms of meteorology, system productivity, and food web composition, all of which have the potential to affect fish community structure and interactions through both density-dependent and independent processes. Whereas Lake Erie's fish community was shown to shift from an assemblage dominated by species tolerant of eutrophic conditions to one that was less tolerant from the late 1960s through the mid-1990s, corresponding to reductions in point-source phosphorus inputs and dreissenid mussel invasion and population expansion, our understanding of how the fish community has responded recently to increased (non-point) phosphorus loading, increased air temperatures, increased hypolimnetic oxygen depletion rates, and a reduction in dreissenid mussel density remains unknown. Here, we use spatially and temporally explicit bottom trawl, limnological, and nutrient loading data collected during summer and fall 1997–2008 to explore how Lake Erie's fish community has changed during the past decade and the mechanisms responsible for these changes. More specifically, we explore the role of abiotic and biotic (top-down vs. bottom-up) processes in driving abundance, guild, and species richness patterns in the

fish community, including both predator and prey species. *Keywords: Eutrophication, Lake Erie, Fisheries.*

CORKUM, L.D., MEUNIER, B., and YAVNO, S., Dept. Biological Sciences, University of Windsor, Windsor, ON, N9B 3P4. **Acoustic, Olfactory and Visual Signals by Parental Males Result in Successful Spawning in the Invasive Round Goby.**

Fish are known to communicate in many ways and commonly use acoustic, olfactory and visual signals. We present the first report of spawning by the invasive round goby in the laboratory. We recorded egg deposition on a nest ceiling by females, as well as egg fertilization and parental care by nesting males (www.uwindsor.ca/goby). During nest defense, males produced agonistic vocalizations and aggressive visual signals to dissuade intruders from entering their nests. Inside the nest, males inspected and ventilated eggs, and in some cases, consumed their own eggs. In a companion study, we determined if reproductive female round gobies were attracted to a combination of olfactory (urine) and visual (silicone dummy model) stimuli, representing reproductive and non-reproductive male round gobies. Females spent significantly more time at a nest with a black reproductive male model compared with a mottled non-reproductive male model. Although there was greater variability in the response by females to male urine than visual stimuli, females spent more time at a nest in response to reproductive versus non-reproductive urine when corrected for water flow. By releasing urine that contains a sex attractant, male round gobies appear to have developed an effective way to attract females to their nests. *Keywords: Fish behavior, Exotic species, Round goby.*

CORREA, P.A.¹, JUST, C.L.², HU, D.², and VAN AKEN, B.¹, ¹West Virginia University, 395 Evansdale Drive, Morgantown, WV, 26506; ²University of Iowa, 4105 Seamans Center, Iowa City, IA, 52242. **Impact of single PCB Congeners on a Soil Bacterial Community and the Expression of Biphenyl Dioxygenase Genes.**

Bacteria play an important role in the remediation of soils contaminated with PCBs. The hypothesis underlying this research was that PCB congeners with different degree of chlorination will affect differently the soil bacterial activity and biodegradation rates. Microcosm experiments were conducted using aerobic soil slurries exposed to different PCB congeners, including PCB-3, 15, 28, and 77, and the mixture Aroclor 1242. After four weeks, the bacterial community and expression of genes involved in PCB degradation were investigated. The relative abundance of bacterial taxonomic groups, as determined by real-time PCR, revealed an increase of β -Proteobacteria and Actinobacteria in all microcosms exposed to PCBs, when compared to non-exposed soil. In addition, exposure to PCB-77 and Aroclor 1242 resulted in higher abundance of α -Proteobacteria and Acidobacteria. Quantification of biphenyl dioxygenase (BPH), a key gene involved in PCB degradation, using real-time PCR showed a higher abundance in microcosms exposed to all PCB congeners, with a marked increase with PCB-15 and 77, when compared to non-exposed soil. Our results suggest that exposure to PCBs enhanced the growth of bacteria having PCB-degrading capabilities and that different PCB congeners have a different impact on the bacterial community and expression of BPH genes. *Keywords: PCBs, Biotransformation, Microbiological studies.*

COTNER, J.B.¹ and BIDDANDA, B.A.², ¹Department of Ecology, Evolution and Behavior, University of Minnesota-Twin Cities, St. Paul, MN, 55108; ²740 W. Shoreline Dr., Grand Valley State University, Muskegon, MI, 49441. **Respiration in the Headwaters of the Laurentian Great Lakes (Superior and Michigan): Insights into the Carbon Cycle.**

Respiration (R) is a seriously understudied component of ecosystem metabolism, despite the fact that it is a major pathway for carbon and energy flow – on par with primary production (P). A series of measurements of planktonic respiration made in the western arm of Lake Superior and in southeastern Lake Michigan over the past decade demonstrates that the major fate of primary production of carbon in these large deep lakes is respiration. Greater rates of respiration prevailed in Lake Michigan over Lake Superior. Other trends that were observed include a gradient of decreasing respiration rate (on a volumetric basis) and increasing respiration rate (relative to ambient primary production) along a gradient of decreasing primary productivity in both of these lakes. Indeed, preliminary evidence from simultaneous measurements of R and P show that R/P ratios were greater in offshore waters relative to near shore waters and that R/P ratios are higher in summer than in winter. In this paper, we discuss some of the spatio-temporal implications of these observed trends to carbon cycling in these two Great Lakes. *Keywords: Lake Michigan, Lake Superior, Carbon cycle.*

CRAIL, T.D., MATHIAS, P.M., GOTTGENS, J.F., and BOSSENBROEK, J.M., The University of Toledo, Department of Environmental Sciences, Toledo, OH, 43606. **Wind-Derived Seiches as a Means for Detecting and Monitoring the Unionid Community in the Western Basin of Lake Erie.**

Wind-derived seiches may be an effective way of detecting and monitoring the unionid mussel community in the western basin of Lake Erie. Atmospheric fronts, moving SW to NE, repeatedly create seiches of a meter or greater that leave large areas of open lake bottom exposed and enable quick detection of unionid mussels, independent of their abundance and density. In two such events (December 2007 and October 2008), we documented eight species of unionids live, all with multiple year classes, and recorded another four species fresh dead, including Ohio state threatened *Obliquaria reflexa* and state species of concern *Truncila truncata*. We documented unionids during seiches along the entire southern shore of Maumee Bay, and in areas on the northern shore of Sandusky Bay, as well as Crane Creek State Park (OH) and Luna Pier (MI) during non-seiche conditions. Many individuals are colonized by dreissenids, albeit at densities much lower than the complete colonization of non-living unionid hard surfaces at these sites. We suggest that novel approaches are needed for detecting and monitoring these native mussels in turbid conditions. *Keywords: Unionids, Lake Erie, Seiche.*

CRANE, T.R. and PEARSON, R.A., Great Lakes Commission, 2805 S. Industrial Hwy., Suite 100, Ann Arbor, MI, 48104. **Great Lakes Regional Water Use Database History and Trends in 2004.**

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

Operational since 1988, the Great Lakes Regional Water Use Database provides information on water uses to fulfill to state and provincial commitments under the 1985 Great Lakes Charter. Aggregated water use information is available for 9 water use categories (e.g., public supply and self-supply domestic, irrigation, livestock, industrial, thermoelectric fossil fuel, thermoelectric nuclear, hydroelectric and other), the 5 Great Lakes basins, 10 Great Lakes states and provinces. This database was designed to be a crude tool to track of water withdrawals, diversions and consumptive use. The most recent year for which water use data was collected is 2004. In total, water withdrawals for the year 2004 were approximately 850 billion gallons per day, or about 3,219 billion liters per day. Self-supplied hydroelectric is the largest single category of withdrawal and represents 95 percent of the total amount of water “withdrawn” in 2004. This presentation will highlight 2004 regional water use trends, setting the stage for the session’s timely focus on the valuation of Great Lakes waters.

Keywords: Diversion, Lake management, Regional analysis.

CREQUE, S.M., BROFKA, W.A., REDMAN, R.A., and CZESNY, S.J., Lake Michigan Biological Station, 400 17th St., Zion, IL, 60099. **Lake Michigan Biological Station: Studying Illinois’s Waters since 1985.**

The Lake Michigan Biological Station (LMBS) was founded in 1985 as part of the Illinois Natural History Survey. LMBS's mission is to conduct applied research to help management of Lake Michigan fisheries, while also using experimental approaches and expanded sampling to further understand Lake Michigan’s ecology. A Creel Survey was the first project, followed by studies of lake trout spawning and yellow perch population structure. Current projects investigate impacts of invasive species and the role of essential nutrients (fatty acids and vitamins) in the food web and their effects on fish reproduction. We also study nearshore community dynamics in diverse habitats, yellow perch recruitment, and evaluate electric dispersal barriers on the Chicago Sanitary and Shipping Canal. LMBS studies provide valuable information to aid fisheries management and also answer broader questions related to Lake Michigan ecology. We also engage in outreach and education activities. Major funding comes from Federal Aid sport fish restoration grants, along with grants from various Great Lakes Agencies. LMBS collaborates with state, federal, and academic entities in the Great Lakes and beyond. Constraints on our research include unsure budget climates, limited space, and logistic difficulties related to studying system as large as Lake Michigan. *Keywords: Fish, Invasive species, Lake Michigan.*

CUHEL, R.L. and AGUILAR, C., Center for Great Lakes Studies, 600 E. Greenfield Ave., Milwaukee, WI, 53204. **Onboard and Online: Interactive Field Sampling from Research Vessel to Classroom via Internet2.**

A model demonstration of 2-way interactive research education and outreach was presented as a paper at the Internet2 Conference in New Orleans during October 2008. The presenters were aboard the RV Neeskay on Lake Michigan over a coastal spawning reef site. Wireless broadband transmission connected the two groups interactively. A combination of real-time sampling including a remotely operated vehicle (ROV) deployment, talking head

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

discussion, and prefabricated video clips was used to broadcast to a live audience. Real-time question and answer segments were possible during the presentation. Live activities included ROV lowering (video camera input), ROV bottom surveys and slurp sampling (ROV camera input), benthic grab sampling (camera-on-a-rope input), and shipboard sample investigation (video camera), all with audio components. During low-action periods (ROV descent, for example) canned video clips from field and lab studies were used to describe "tedious measurements" that participants accomplish post-cruise. Additional footage of other sites expanded the subject area, and a short segment on cruise preparation educated the audience further about behind-the-scenes activities. *Keywords: Mussels, Environmental education, Coastal ecosystems.*

CULLER, B.M.¹, HUNTLEY, M.², ELMER, H.³, RIDDLE, C.M.⁴, JENTES BANICKI, J.², LICHTKOPPLER, F.², VAN ZOEST, P.³, and MANZO, L.², ¹ODNR Office of Coastal Management, 105 W. Shoreline Drive, Sandusky, OH, 44870, US; ²Ohio Sea Grant College Program, 1314 Kinnear Road, Area 100, Columbus, OH, 43212-1156, US; ³ODNR Old Woman Creek NERR, 2514 Cleveland Road East, Huron, OH, 44839, US; ⁴Ohio Lake Erie Commission, One Maritime Plaza, 4th Floor, Toledo, OH, 43604, US. **Lake Erie Literacy Principles: How PIs Can Incorporate Literacy Principles and Outreach Components to Enhance Research Proposals.**

This presentation will provide an overview of the eight Lake Erie Literacy Principles and the fundamental concepts addressed within them. Adapted from NOAA's Ocean Literacy framework, the Lake Erie Literacy Principles have been regionalized to increase their relevance to local citizens. Ohio's NOAA-funded partners and the Lake Erie Commission are in the process of adopting Principles as a guide to the knowledge necessary to be a Lake Erie literate citizen, one who can communicate about the Lake and can make informed decisions regarding the Lake and its resources. Many funding agencies require scientists to add education and outreach components into their research proposals, yet scientists often struggle when explaining the broader impact of their work on constituents in their regions. The purpose of sharing these Principles is to assist scientists in incorporating Lake Erie education and outreach into their grants and to suggest potential partners and activities to boost their grant-seeking success. Referencing Lake Erie Literacy Principles allows funding sources to see where specific scientific research fits into the wider spectrum of educating the public about Lake Erie issues.

Keywords: Coastal ecosystems, Education, Lake Erie.

CULLER, B.M.¹, HUNTLEY, M.², ELMER, H.³, RIDDLE, C.M.⁴, JENTES BANICKI, J.², LICHTKOPPLER, F.², VAN ZOEST, P.³, and MANZO, L.², ¹ODNR Office of Coastal Management, 105 W. Shoreline Drive, Sandusky, OH, 44870, US; ²Ohio Sea Grant College Program, 1314 Kinnear Road, Area 100, Columbus, OH, 43212-1156, US; ³ODNR Old Woman Creek NERR, 2514 Cleveland Road East, Huron, OH, 44839, US; ⁴Ohio Lake Erie Commission, One Maritime Plaza, 4th Floor, Toledo, OH, 43604. **From the Ocean to the Lake: Introducing the Lake Erie Literacy Principles.**

The Ocean Literacy Essential Principles and Fundamental Concepts were published in 2006. Sponsored by NOAA, COSEE, NMEA and the National Geographic Society, they represent the knowledge understood by an ocean-literate citizen. While the Great Lakes are an integral part of Earth's one ocean, the freshwater nature of the lakes makes them chemically, geologically and biologically unique from their saltwater counterparts.

Education/outreach/extension personnel in Ohio have found that residents in the Lake Erie region sometimes find it difficult to grasp the true meaning of the Ocean Literacy Principles because of the differences in freshwater and saltwater ecosystems. Therefore, the Lake Erie Commission and various NOAA-funded agencies in Ohio collaborated to adapt the Ocean Literacy Principles to make them more tangible and relevant to citizens/decision makers living in the Lake Erie watershed. This poster will familiarize researchers with the Lake Erie Literacy Principles framework. The Principles and their Fundamental Concepts are intended to be used by scientists in two ways: (1) to help improve funding opportunities by strengthening the education/outreach component of grants, and (2) to give researchers an alternative perspective on how their work might fit into the broad complexity of understanding the Lake Erie ecosystem.

Keywords: Education, Coastal ecosystems, Lake Erie.

CUSTER, K.W.¹, BURTON, G.A.², TAULBEE, K.², FETTERS, K.¹, HUMMEL, S.¹, and SCHLEKAT, C.³, ¹Wright State University, Department of Earth and Environmental Sciences, Dayton, OH; ²University of Michigan, School of Natural Resources and Environment, Ann Arbor, MI; ³Nickel Producers Environmental Research Association (NiPERA), Durham, NC.

Aquatic Insect Responses to Nickel Spiked Sediments: *In Situ* and Laboratory Exposures.

Indigenous aquatic insect responses to nickel spiked sediments is an area of research that has been overlooked. Examining the effects on these representative groups will help to understand nickel toxicity. Mayfly (*Anthopotamus verticis*, *Isonychia spp.*, and *Stenonema spp.*) and beetle (*Psephenus herricki*) larvae were exposed both *in situ* (Greenville Creek), and in a lab flow through system. Greenville Creek sediments (low in acid volatile sulfides and organic carbon) were used to examine nickel toxicity. *Anthopotamus verticis*, *Isonychia spp.*, and *P. herricki* showed no survival or growth effects during the *in situ* tests. Lab tests showed *A. verticis* and *Stenonema spp.* growth (weights and exuvia) and survival (p-value <0.001), and *Isonychia spp.* survival were all significantly different (p-value = 0.026). Threshold effects for the lab sediment tests showed an EC₁₀ of 212 mg/kg for *A. verticis*, an EC₁₀ of 338 mg/kg for *Stenonema spp.*, and EC₁₀ of 1398 mg/kg for *Isonychia spp.* *In situ* tests are not demonstrating the toxicity being seen in the laboratory tests. However, *in situ* tests experience environmental relevant conditions, and nickel bioavailability may be lessened under these conditions.

Keywords: Benthos, Metals, Sediments.

CUTHBERT, F.J.⁵, EWERT, D.N.¹, HARKNESS, M.³, KRAUS, D.T.⁴, MYSOREKAR, S.⁶, SEYMOUR, M.M.², SLAATS, J.³, SOBASKI, S.¹, VIGMOSTAD, K.E.⁷, WHITE, G.A.⁴, and WIRES, L.R.⁵, ¹The Nature Conservancy, 101 East Grand River, Lansing, MI, 48906; ²U.S. Fish and Wildlife Service, 4625 Morse Rd., Suite 104, Columbus, OH, 43230; ³The Nature Conservancy, 1101 West River Parkway, Suite 200, Minneapolis, MN, 55415; ⁴Nature Conservancy of Canada - Ontario Region, RR#5, 5420 Highway 6 North, Guelph, ON, N1H 6J2;

⁵Univ. of Minnesota, Dept. of Fisheries, Wildlife, and Conservation Biology, 1980 Folwell Avenue, St. Paul, MN, 55108; ⁶The Nature Conservancy, 8 South Michigan Avenue, Suite 900, Chicago, IL, 60603; ⁷Northeast-Midwest Institute, 50 F Street, NW #950, Washington, DC, 20001. **Landscape-Level Conservation of Great Lakes Island Biodiversity.**

More than thirty thousand islands of the Great Lakes form the world's largest collection of freshwater islands and their ecological significance is of global importance. They make a unique contribution to the biodiversity of North America and include a high proportion of provincial and state endemic species, rare communities, specialized biological functions and unique ecological phenomena. Many islands are under threat from incompatible development, invasive species and intensive recreation. Conservation of Great Lakes islands is important for maintaining the biodiversity of the region. Large islands and island complexes in the Great Lakes have been organized by coastal environment and scored for 20 biodiversity criteria that include rare species and communities, physical diversity, shape complexity and distinctiveness. Islands were also assigned scores based on threats, existing land protection and conservation policy. Results from this work can be used to better identify islands and island complexes that have exceptional biodiversity values and may require a more urgent conservation focus due to impending threats. This work includes islands in both the U.S. and Canada and will enhance our understanding of the biodiversity and conservation needs of islands within the entire Great Lakes basin. *Keywords: Great Lakes basin, Islands, Biodiversity, Spatial analysis.*

CZAJKOWSKI, K., AMES, A., and AULT, T., Department of Geography and Planning, University of Toledo, Toledo, OH, 43606. **Use of GIS to Analyze the Potential Health Impacts of the Application of Sewage Sludge to Agricultural Fields in Northwest Ohio.**

This presentation will review the research work of a project to investigate the potential human health impacts of sewage sludge application on agricultural fields in Northwest Ohio. Environmental impacts through pathogens, nutrients, heavy metals and pharmaceuticals from sludge application have been studied in relation to the soils, water running off of applied fields and aerosols emitted into the air. We are investigating the transport of pathogens and heavy metals from sludge amended fields through bioaerosol and particulate matter sampling. Epidemiological studies focusing on families living near sludge-amended fields have been conducted. Geographic information system (GIS) databases have been developed to assist with the project and the analysis of the data collected. A GIS database was created to extract addresses for people living near and on agricultural fields permitted for sewage sludge application. Data layers of EPA permitted fields, sewage sludge application as well as readily available datasets such as soils, land cover, population, parcel data, roads, waterways, schools, soil data, biosolids permitted fields, and biosolids application rates. Challenges encountered while working with datasets across the state will be discussed. *Keywords: GIS, Human health, Biosolids.*

D'SOUZA, N.¹, WILHELM, S.W.², TWISS, M.R.³, CARRICK, H.J.⁴, BOURBONNIERE, R.A.⁵, BULLERJAHN, G.S.¹, and MCKAY, R.M.L.¹, ¹Department of Biological Sciences, Bowling Green State University, Bowling Green, OH, 43403; ²Department of Microbiology, The

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University of Tennessee, Knoxville, TN; ³Department of Biology, Clarkson University, Potsdam, NY; ⁴School of Forest Resources, Pennsylvania State University, University Park, PA; ⁵Environment Canada, Canada Centre for Inland Waters, Burlington, ON. **Primary Production in Ice-Covered Lake Erie.**

Limnological surveys of Lake Erie were undertaken in February 2007/2008 when the lake was ~90% ice covered. During winter, the lake supported high phytoplankton biomass dominated by nutrient sufficient, low-light adapted, filamentous, centric diatoms of the species *Aulacoseira islandica* (O. Müller) Simonsen. An April 2008 survey demonstrated that high *Aulacoseira* spp. biomass persisted into spring. During each cruise, samples were analyzed for dissolved nutrients and elemental stoichiometry (C, N, P) of seston. Rates of primary production were measured using dual proxies including [14C]-bicarbonate uptake and photosynthetic oxygen evolution. Total light-saturated winter primary production estimated by [14C]-uptake ranged from 1–7 g C/g Chla*h, whereas net photosynthetic oxygen evolution of net plankton ranged from 0.05–2.5 mol O₂/g Chla*h. Photosynthesis vs. irradiance curves obtained using both approaches yielded median E_k values of 29 ([14C]-uptake) and 44 (O₂ evolution) μmol photons/m²*s respectively, suggestive of a low light-adapted community. Our findings support the existence of a physiologically robust assemblage of psychrophilic diatoms in Lake Erie, the contributions to carbon cycling of which must be considered when deriving whole lake carbon budgets. *Keywords: Lake Erie, Ice, Diatoms.*

DAGGUPATY, S.M., BANIC, C.M., and BLANCHARD, P., Air Quality Research Division - Environment Canada, 4905 Dufferin Street, Toronto, ON, M3H 5T4. **Numerical Simulation of Atmospheric Loadings of Mercury from a Coal Fired Power Plant to Lake Erie.**

Loadings of atmospheric mercury to Lake Erie were numerically simulated with the use of speciated Hg emissions from a coal fired power plant on its Ontario shore. 3-d numerical modeling experiments to simulate meteorology and speciated Hg air concentration, wet and dry deposition, and air-water exchange were conducted using the Boundary Layer Forecast Mesoscale and Air Pollution prediction System (BLFMAPS). For most emission scenarios, reactive gaseous mercury (RGM) was found to be the dominant contributor to the Lake Erie Hg loading. The contribution of particulate Hg was relatively small. 28% of coarse particle and 7% of fine particle emissions were deposited within 100 km of the power plant. Our experiments also suggest that an emissions scenario with a larger GEM fraction (~90% of total Hg emissions) will yield the least amount of total Hg loading to Lake Erie. Comparison of modeled surface air concentrations and total loadings with measured values from CAMNet (Canadian Atmospheric Mercury Network) and MDN (Mercury Deposition Network of the US National Atmospheric Deposition Program, NADP) suggest that the power plant contributes less than 15% of the total atmospheric Hg deposition to the lake. *Keywords: Model studies, Deposition, Mercury.*

DAI, Q.¹ and DEMARCHI, C.², ¹2350 Hayward, Ann Arbor, MI, 48109-2125; ²10900 Euclid Ave, Cleveland, OH, 44106-7216. **Estimating Over-lake Precipitation in the Great Lakes Combining Radar and Rain Gages.**

Over-lake precipitation is a key component of the Great Lakes' water balance. Its estimation is, therefore, vital for planning and operational purposes. Yet, reliable over-lake precipitation estimates are difficult to obtain because the lack of gages on the lakes themselves and the scarcity of gages in parts of the draining basins. Traditionally, over-lake precipitation has been estimated by distance-weighted interpolation methods. In spite of their wide acceptance, these methods suffer from intrinsic limitations as they fail to take into account the spatial variability of rainfall. Recently, an operational multisensor product combining radar-based precipitation estimates and rain gage data, the National Centers for Environmental Prediction Multisensor Precipitation Estimates(MPE) have provided a suitable alternative to estimates based on the sparse gage data. However, the presence of biases and inconsistencies in the MPE data has raised serious concerns about their accuracy. This paper analyzes the applicability of MPE for estimating monthly over-lake precipitation in the Great Lakes basin, and presents some techniques for overcoming its limitations by spatially integrating MPE data with gage observations. Further, an analysis of the uncertainty of the popular NOAA GLERL estimates of over-lake precipitation is also presented. *Keywords: Over-lake precipitation, Radar, Net basin supply.*

DALEY, B.A.¹, MANNY, B.A.², KENNEDY, G.W.², ROSEMAN, E.F.², CRAIG, J.M.², and BLACK, G.M.², ¹University of Michigan, School of Natural Resources and the Environment, Ann Arbor, MI, 48109; ²USGS-Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105. **Substrate Preference and Status of the Endangered Northern Madtom (*Noturus stigmosus*) in the Upper Detroit River.**

The northern madtom is a small Ictalurid catfish native to North America with small, isolated populations in the Lake Erie and Ohio River basins. A globally vulnerable species, it is endangered in Michigan and Ontario. However, our ability to conserve or restore northern madtom populations is hindered by a lack of information on the ecology of this species. Since 2003, a few northern madtom have been captured on rock reefs constructed near the head of Belle Isle in the Detroit River. Because madtoms are cavity spawners, the availability of substrates suitable for cavity nesting may be a critical resource. We explored this hypothesis by comparing temporal changes in the abundance of northern madtoms and other fish species between habitats with differing levels of substrate heterogeneity. Fish were collected twice a month from Jun.-Aug. 2008 using baited minnow traps set at the 3 rock reef sites and 4 nearby sand/silt substrate sites. Round gobies dominated the fish assemblage in both habitat types, and were most abundant at the reef sites on the last four sampling dates. 208 northern madtoms were collected, but no significant difference in madtom numbers were detected across habitats or sampling dates. 4 YOY madtoms were collected, suggesting that they are reproducing in the upper Detroit River *Keywords: Conservation, Detroit River, Fish populations.*

DATE, K., Cleveland State University, 2121 Euclid Avenue, Cleveland, OH, 44115. **The Lake Erie Balanced Growth Program – Best Local Land Use Practices.**

The Lake Erie Protection & Restoration Plan was adopted by the Ohio Lake Erie Commission in 2000. The Plan, which was prepared with the participation of many Lake Erie

stakeholders, concluded that the “quality of Lake Erie is a reflection of the quality of the entire watershed.” A Blue Ribbon Task Force came together to establish two documents, which guide the implementation of the Balanced Growth Program, under the title “Linking Land Use and Lake Erie”. The second document, “Best Local Land Use Practices”, established 17 different subject areas where local government decisionmaking can directly affect the quality of water in Lake Erie through impacts to watershed land use. Ranging from development practices such as conservation development and compact development, to protection measures for stormwater management, woodlands, meadows, steep slopes, and scenic areas, these practices form the backbone of a sustainable zoning and planning program for local governments in Ohio. An implementation phase of the Program is currently underway, with educational efforts, case study development, and hands-on technical assistance for individual communities. *Keywords: Policy making, Watersheds, Lake Erie.*

DE SILVA, A.O., SMALL, J., WILLIAMSON, M., BACKUS, S., and MUIR, D.C.G., Water Science and Technology Directorate, Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Perfluorinated Acids in Lake Ontario Trout: 1997 – 2007.**

Since 2000, PFOSF (C₈F₁₇SO₂F) based products have been phased out while fluorotelomer (FT) based production has increased. We hypothesize that these production changes would result in declining PFOSFs and increasing FT degradation products, the perfluorinated acids (PFAs), in Lake Ontario trout. Previous studies (Martin et al 2004; Furdui et al 2008) had insufficient samples post 2001 to address this issue. Annual (1997 – 2007, 8 fish/y) lake trout from Lake Ontario, collected as part of the National Fish Contaminants Monitoring and Surveillance Program (NFCMSP), Environment Canada, were analyzed for PFAs including the carboxylates: (F(CF₂)_xC(O)O-), PFOA (x = 7), PFNA (x = 8), PFDA (x = 9), PFUnA (x=10), PFDoA (x=11), PFTrA (x=12), PFTA (x=13), and PFPeA (x=14), and sulfonates: (F(CF₂)_ySO₃-), PFHxS (y = 6), PFOS (y = 8), PFDS (y = 10) and PFOSA (F(CF₂)₈SO₂NH₂). The sample set comprised of 8 fish/y. The PIA statistical tool (Bignert, 2007) was used to assess temporal trends of log transformed concn. PFUnA, PFTA, and PFPeA were all observed to increase in concentration with doubling times corresponding to 10, 14, and 6 y (p<0.05), respectively. No significant trends were observed in other carboxylates. PFOSA decreased over time (T_{1/2} 4 y). Significant decreases in PFDS (T_{1/2} 3 y) and PFHxS (T_{1/2} 6 y) were observed in '00. *Keywords: Trout, Perfluorinated acids, Biomonitoring.*

DE TEZANOS PINTO, P. and LITCHMAN, E., 3700 E Gull Lake Dr, Kellogg Biological Station, Hickory Corners, MI, 49060. **Interactive Effects of N:P Ratios and Light on Nitrogen-fixing Cyanobacteria.**

Many harmful cyanobacterial species are nitrogen-fixers that can contribute significant amounts of nitrogen and impact ecosystem functioning in diverse aquatic ecosystems. What determines N-fixer abundance remains poorly understood. Here we experimentally investigate major environmental controls on the abundance of N-fixers: nitrogen to phosphorus (N:P) ratio and light. We grew a N-fixer, cyanobacterium *Anabaena flos-aquae*, in a multispecies community of freshwater phytoplankton in replicated factorial design treatments with two N:P

ratios and two light levels. We show that low N:P ratios promote the dominance of the N-fixer in the community, but only under high light. Under low light, N:P ratio did not have a significant effect on the abundance of the N-fixer. N fixation occurred at low N:P only and increased with increasing light. In contrast, the density of non N-fixing cyanobacteria did not depend on N:P ratios. Green algae dominated under high N:P and high light only, exhibiting the opposite pattern of dominance to N-fixers. Species diversity depended on the N:P ratio at high light and was lower when the N-fixer dominated. These results are consistent with patterns observed in nature and help explain the N-fixer distribution along the environmental gradients of nutrients and light. *Keywords: Cyanophyta, Nutrients, Biodiversity.*

DEL GOBBO, L.C.¹, ARCHBOLD, J.A.³, VANDERLINDEN, L.³, ECKLEY, C.², TOMY, G.⁴, and DIAMOND, M.L.², ¹School of Dietetics & Human Nutrition, McGill University, Montreal, QC; ²Department of Geography, University of Toronto, Toronto, ON, M5S 3G3; ³Environmental Protection Office, Toronto Public Health, Toronto, ON, M5B 1W2; ⁴Freshwater Institute, Department of Fisheries and Oceans, Winnipeg, MB, R3T 2N6. **How Much of Which Fish Should We Eat? Consumption Guidance for Toronto Market Fish Based on Contaminants and Omega-3 Fatty Acids.**

Fish consumption by pregnant women confers benefits and risks to the developing fetus. Docosahexaenoic acid (DHA) from fish may promote fetal neurodevelopment while methylmercury (MeHg) can have adverse effects. To assess how these potential benefits and risks could be balanced in fish frequently consumed, we sampled 18 fish species from Toronto retail markets that serve southeast Asian and Caribbean populations. Raw fish fillets were analysed for total Hg, PCBs, legacy organochlorine compounds and omega-3 fatty acids. Consumption scenarios that balance nutritional benefits from consuming DHA and potential risks from MeHg and organochlorines were developed using guidance from Toronto Public Health and other sources, based on 75 g portions defined by the Canada Food Guide. We determined that women of childbearing age can remain below the toxicological benchmark for Hg by consuming 9 of 18 fish species daily (14 servings/wk) or often (up to 4 servings/week). Women can get the DHA level recommended by Koletzko et al. (2008) by consuming 7 of those 9 fish species. We estimated maternal women can attain sufficient levels of DHA through fish consumption alone without the need for supplementation or by posing a risk to childbearing women (or the fetus) from mercury. *Keywords: Human health, Fish.*

DEMARCHI, C.¹, MELLO, M.E.², and HUNTER, T.S.³, ¹Department of Geological Sciences, Case Western Reserve University, 10900 Euclid Ave, Cleveland, OH, 44106-7216; ²Cooperative Institute for Limnology and Ecosystems Research, University of Michigan, 440 Church St, Ann Arbor, MI, 48109-1041; ³NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Rd, Ann Arbor, MI, 48108-9719. **Estimating Lake-Wide Runoff Uncertainty in the Great Lakes Using a Monte Carlo Technique.**

Tributary flow is a key component of the Great Lakes' water balance, roughly equivalent in magnitude to direct over-lake precipitation and evaporation. Its estimation is, therefore, vital for planning and operational purposes. Given the extension and the scarcity of islands of the

Great Lakes, runoff should be the least uncertain component in the net basin supply estimates. As part of the International Upper Great Lakes Study, we analyzed the algorithm used by the NOAA Great Lakes Environmental Research Laboratory to estimate tributary flow to the Great Lakes and evaluated its uncertainty using a Monte Carlo technique. Preliminary results indicate that uncertainty is relatively small for Lake Erie and Lake Michigan, but quite larger for Lake Superior, Lake Huron, and Georgian Bay. This is due to the fact that several major basins in the drainage basin of these three lakes are not monitored or just partially monitored.

Keywords: Tributary runoff, Uncertainty, Nutrients, Net basin supply.

DEPEW, D.C.¹, HOUBEN, A.¹, OZERSKY, T.¹, HIGGINS, S.N.², HECKY, R.E.³, GUILDFORD, S.J.³, SMITH, R.E.H.¹, and MALKIN, S.Y.¹, ¹Biology Dept, University of Waterloo, Waterloo, ON, N2L 3G1; ²Center for Limnology, University of Wisconsin, Madison, WI; ³Biology Dept and Large Lakes Observatory, University of Minnesota, Duluth, MN, 55812.

***Cladophora* Distribution in Lake Ontario Nearshore Environments: Implications for Nutrient Management Strategies.**

The return of widespread *Cladophora* blooms to the nearshore of the lower Great Lakes has been linked to the invasion and subsequent ecosystem alterations by dreissenid mussels. In addition, the Lake Ontario catchment has undergone rapid changes in land use and population density. With an increase in population comes a pressing need to manage increasing levels of anthropogenic waste (i.e STP upgrades, urban runoff, agricultural nutrient management). We report here results from multiple years (2005-2007) of water quality and hydroacoustic surveys in Lake Ontario spanning a gradient from the urbanized western basin, eastward along the north shore to a more rural Presqu'ile Provincial Park, ending at a shoal in the open lake.

Keywords: Management, Lake Ontario, Cladophora.

DEPEW, D.C.¹, SILSBE, G.M.¹, SMITH, R.E.H.¹, HECKY, R.E.², and GUILDFORD, S.J.², ¹Biology Dept, University of Waterloo, Waterloo, ON, N2L 3G1; ²Dept of Biology and Large Lakes Observatory, University of Minnesota, Duluth, MN, 55812. **Probing the Phytoplankton of Nearshore Lake Ontario.**

The coastal areas of Lake Ontario receive a variety of inputs from the surrounding catchments. Tributary discharge, municipal water treatment discharge and the close proximity to the benthos exposes nearshore phytoplankton to a diversity of potential impacts. Fast Repetition Rate Fluorometry was used to assess the physiological state of nearshore Lake Ontario phytoplankton during day and nighttime surveys at two sites during 2006 and 2007. Spatial analysis of the main patterns of variation and relation to potential factors of influence will be discussed. *Keywords: Productivity, Lake Ontario, Algae.*

DEPINTO, J.V.¹, AUER, M.T.², REDDER, T.R.¹, VERHAMME, E.M.¹, and RUCINSKI, D.K.¹, ¹LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108; ²Michigan Technological University, Houghton, MI, 49931. **Coupling the Great Lakes *Cladophora* Model (GLCM) with a Whole Lake Eutrophication Model (AEM3D).**

The recent reoccurrence of *Cladophora* and other nearshore nuisance algal blooms throughout much of the Great Lakes has generated renewed interest in modeling the phenomenon. A revised version of the GLCM has been used to quantify the relationship between the supply of available phosphorus and *Cladophora* production as well as how that relationship changes as a function of light availability. This model can be used to inform phosphorus control decisions only if it can be coupled to a model that provides the supply of available phosphorus and light to a given shoreline area as a function of lakewide nutrient loadings and the processing of those nutrients in the rest of the lake. We have accomplished this nearshore – offshore coupling by incorporating the GLCM into our linked 3D hydrodynamic – nutrient - lower food web – dreissenid model (AEM3D). This presentation will describe how this coupling has been accomplished and will provide several examples of how the full model framework can provide a quantitative relationship between phosphorus loading and *Cladophora* production.

Keywords: Cladophora, Eutrophication, Nutrients.

DEROBA, J.J. and BENCE, J.R., Michigan State University Dept. of Fisheries and Wildlife, 13 Natural Resources Building, East Lansing, MI, 48824. **Evaluating Harvest Control Rules When Life History Varies: The Case of Lake Whitefish in the Great Lakes.**

Lake whitefish support a commercial fishery in the Great Lakes and experience spatial and temporal variation in life history traits, such as size-at-age. Currently, the fishery is managed by attempting to maintain a constant mortality rate. We used an age-structured simulation model that incorporated stochasticity in life history traits and multiple sources of uncertainty to compare the current strategy with a range of alternative control rules, including conditional constant catch (CCC), constant fishing rate (CF), biomass-based (BB), and CF and BB rules with a 15% limit on the interannual change in the total allowable catch (TAC). With appropriate policy parameters the CF and BB rules can simultaneously attain higher average yield and spawning stock biomass than all other control rules. The CCC rule and limiting the CF or BB rules to a 15% change in TAC had the lowest yearly variability in yield, and their performance in this regard improved with high assessment error. For control rules using policy parameters that produced the same yield, biomass more often reached low values when TAC changes were limited to 15% and least often for the BB rule. The low yearly variability in yield provided by limiting TAC changes to 15% comes at the cost of frequently reducing biomass to low levels.

Keywords: Fish populations, Harvest control rules, Fish management, Lake whitefish, Uncertainty.

DEVANNA, K.M., ARMENIO, P.M., and MAYER, C.M., Department of Environmental Sciences and the Lake Erie Center, The University of Toledo, Toledo, OH, 43618. **Biotic and Abiotic Habitat Interactions Determine Predation Risk for Burrowing Mayflies.**

Larval burrowing mayflies (*Hexagenia* spp.) are an important food source for many fish species and are an indicator of good ecosystem health. Two environmental factors: invasive dreissenid mussels (zebra and quagga mussels) and low dissolved oxygen levels (hypoxia), may affect mayfly behavior and their availability to fish as a food source. Behavioral observations

showed that in well oxygenated water mayflies chose the structured habitat provided by *Dreissena* clusters over bare sediment; most likely as protection from predation. Laboratory foraging experiments showed that *Hexagenia* do derive protection from predation by round gobies and yellow perch in *Dreissena*-covered sediment when turbidity is held at a similar level to what is commonly seen in western Lake Erie. However, during hypoxia, mayflies left the protection of the sediment or mussel clusters, making themselves vulnerable to predation. Interestingly, when fish were present fewer mayflies left bottom refuge initially, but prolonged hypoxia forced mayflies out of the bottom sediments. These results suggest that the presence of *Dreissena* lowers the availability of *Hexagenia* to fish in well-oxygenated conditions, although during low oxygen conditions mayflies are forced to leave their burrows and risk being preyed upon. *Keywords: Invasive species, Burrowing mayflies, Food chains, Predation, Anaerobic conditions, Dreissena.*

DIGGINS, T.P., Youngstown State University, Department of Biological Sciences, Youngstown, OH, 44555. **Invasive Species and a Fundamental Reordering of Spatial Dynamics in the Nearshore Benthos of the North American Great Lakes.**

The Laurentian Great Lakes are among the world's most invaded freshwater ecosystems. The nearshore benthos in particular is dominated by invasives. One consequence has been the emergence of new patterns of benthic spatial organization. The ubiquitous presence of attached sessile animals (i.e. dreissenid mussels) is historically unique in North American fresh waters. Never before has so large a system as the Great Lakes been densely settled by organisms that tenaciously occupy space and that markedly restructure the environment. While the study of invasives-driven spatial interactions (e.g. interference competition) has been less extensive than that of resource exploitation, evidence is intriguing: structuring effects on predator/prey dynamics (e.g. potential prey refugia), spatial niche partitioning (invasive vs. native amphipods, quagga vs. zebra mussels), influence of invasive and possibly keystone predators (round goby predation on dreissenids and other benthic invertebrates), and rapid colonization by dreissenids of new settling substrata (debris, unionid mussels, nascent mussel clusters). Such apparently novel processes may be creating a nearshore Great Lakes benthic environment that increasingly resembles ecologically (although obviously differs hydro-dynamically and chemically) a marine inter-tidal zone. *Keywords: Invasive species, Benthos, Spatial distribution.*

DOBIESZ, N.E.¹, LAWRENCE, T.J.³, and MKUMBO, O.C.², ¹University of Minnesota, 2205 East 5th St. RLB 109, Duluth, MN, 55812; ²Lake Victoria Fisheries Organization, Plot No. 7B/7E Busoga Square P.O. Box 1625, Jinja, Uganda; ³School of Natural Resources and Environment, University of Michigan, Ann Arbor, MI. **Comparing the Socio-Economic Drivers of Fisheries Management Practices between Lake Victoria and the Laurentian Great Lakes.**

Global demand for fish protein is increasing. This pressure is creating escalating economic incentives to cultivate these resources, often with adverse affects to the ecological and socio-cultural welfare associated with them. Fisheries management has increasingly become an act of balancing economic and livelihood benefits with those of ecosystem health. Successful

fisheries management strategies on common property and multi-jurisdictional fisheries accommodate numerous stakeholders, while also maintaining the integrity of the fish stocks and the ecosystem. These strategies, however, are not constant across resources globally; what works in one region is not necessarily the best solution in another region. Management strategies differ based on political, economic, cultural, and socio-economic drivers. In this body of work we examine fisheries management approaches and policies employed on Lake Victoria, East Africa versus those of the Laurentian Great Lakes to determine why approaches differ between the two, and if these differences necessitate alternate management approaches. Finally, we ask what can be learned by managers from each region about the other's approaches. *Keywords: Great Lakes basin, Fish management, Lake Victoria.*

DOKA, S.E.¹, RANDALL, R.G.¹, KOOPS, M.A.¹, CHU, C.², and JOHNSON, T.³, ¹Fisheries & Oceans Canada, 867 Lakeshore Rd. Box 5050, Burlington, ON, L7R 4A6; ²Trent University, Peterborough, ON; ³Ontario Ministry of Natural Resources, Picton, ON. **The Role of the Nearshore for Fishes in Lake Ontario: DFO's Lake Ontario Ecosystem Research Initiative.**

Research and monitoring in Lake Ontario is mainly conducted offshore and in select embayments. Therefore, the role of the nearshore in lake dynamics is poorly understood. Nearshore habitats serve as nursery and feeding areas for many fishes. Biodiversity and productivity are linked to habitat diversity and availability, and physico-chemical dynamics. This zone is also the interface with human development in coastal areas and inflowing watersheds whereby both rapid and long-term changes have occurred at different spatial scales. More attention to their impacts is needed. Examples of current stressors include; water regulation, aquatic invasive species, and habitat alteration or loss. In the future, the already variable nearshore will be affected by accelerating climate change. It is unclear how the cumulative impacts of multiple stressors have and will affect nearshore function in the Lake Ontario ecosystem. Therefore the goals of the Ecosystem Research Initiative build on existing research and partnerships to (i) evaluate how nearshore areas contribute to the whole lake, (ii) assess the sensitivity of the nearshore to cumulative impacts from multiple stressors, and (iii) project how the nearshore may respond to future conditions. *Keywords: Model studies, Lake Ontario, Trophic level.*

DOLAN, D.M., University of Wisconsin - Green Bay, Natural and Applied Sciences, Green Bay, WI, 54311. **Spatially Detailed Nutrient Load Estimates for Lake Erie in 2005.**

Although it is the smallest of the Great Lakes, Lake Erie receives the greatest loading of many nutrients including total phosphorus. The Ohio Tributary Monitoring Network established by the National Center for Water Quality Research at Heidelberg College continues to collect one to three samples per day for nutrients and sediment at sites on six Lake Erie tributaries. The resulting nutrient data from this program combined with other data sources allows for the estimation of daily load time series for 26 spatial nodes around the lake as required by ecosystem modelers at the NOAA-Great Lakes Environmental Research Laboratory for the ECOFORE 2006 project. Estimates have been made for nitrate plus nitrite, soluble reactive phosphorus, total

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

suspended solids, total Kjeldahl nitrogen, and total nitrogen. *Keywords: Nutrients, Pollution load, Lake Erie.*

DOMSKE, H.M., New York Sea Grant - Cornell University, 228 Jarvis Hall, SUNY Buffalo, Buffalo, NY, 14260-4400. **COSEE – GL: Shipboard Science on the USEPA R/V Peter Wise Lake Guardian.**

The Center for Ocean Science Education Excellence - COSEE GL (Funded by NSF and NOAA) has teamed up with the USEPA and its research vessel, the R/V *Peter Wise Lake Guardian*, to provide a unique learning experience for teachers who infuse Great Lakes topics into their classrooms. This presentation will provide an overview of the 2008 summer cruise that brought 16 teachers from New York, Ohio, Illinois, Michigan and Minnesota; 10 Scientists and 4 Sea Grant Educators together for a week-long voyage on the waters of Lake Ontario. This shipboard science experience helped to facilitate collaboration between scientists and educators, as well as enhancing teacher capabilities in science. Learn about this exciting educational opportunity from one of the Sea Grant educators who took part in this voyage and see how you can get involved in upcoming sessions on the other Great Lakes. *Keywords: Environmental education, Lake Ontario, Outreach.*

DOMSKE, H.M.¹ and EDWARDS, W.J.², ¹New York Sea Grant, 228 Jarvis Hall - SUNY Buffalo, Buffalo, NY, 14260; ²Niagara University, Lewiston, NY, 14109. **Making the Most out of a Classroom Visit.**

Being invited to visit a middle or high school classroom may create anxiety for Great Lakes researchers who are accustomed to dealing with undergraduate and graduate students on a daily basis. Although the classroom visit can be a challenge for a researcher, it can be a memorable experience for young students who may not have had the chance to interact with a working scientist. This presentation will provide techniques and suggestions for scientists who are invited into classrooms, so their visit can be worthwhile and enjoyable for the students and researcher as well. Classroom visits can also help researchers hone their skills of sharing technical information with non-technical audiences. Interactions with younger students can spark a real interest in learning more about scientific fields. The session will provide tips to prepare researchers for a visit with younger, energetic students. *Keywords: Education, Outreach, Environmental education.*

DONG, N. and PENNUTO, C.M., Biology Department, Buffalo State College, 1300 Elmwood Ave., Buffalo, NY, 14222. **Effects of Experience and Age on Predator Avoidance Behavior of Crayfish in Lake Erie.**

Chemical cues released by predators are important stimuli to induce avoidance behaviors of prey in aquatic environments. Pilot studies showed that alarm cue avoidance was innate in the crayfish, *Orconectes propinquus*, and that *O. propinquus* can learn to avoid novel predators by associating predator odor with conspecific alarm cues. Associative learning occurs early in

crayfish development. Two-month old, predator-naïve *O. propinquus* avoided goldfish-scented water and moved less than when exposed to unconditioned water. Experience and age had a significant effect on the length of a learned association. One-year old, predator-naïve animals avoided novel predators for 3 days following training, whereas predator-experienced, 1-year old animals avoided novel predators for 5 days. Similarly, one-year old predator-naïve animals showed a higher inclination to avoid goldfish-scented water than six-month old predator-naïve ones over the first 3 days after training. Results of these studies could provide insights into how invasive crayfish species might respond to novel predators in new habitats. Adult invaders should be better able to succeed in the face of novel predators compared to juvenile or inexperienced crayfish. *Keywords: Predation, Crustaceans, Invasive species.*

DONNELLY, K.A., Great Lakes Commission, 2805 S. Industrial Hwy, Suite 100, Ann Arbor, MI, 48104. **Potential Impacts of Offshore Wind Farms in the Great Lakes: Lessons Learned from the European Experience and Suggestions for the Future.**

The issues of climate change and energy security have caused a dramatic increase in proposals for renewable energy projects in both North America and abroad. The development of certain alternative energies, such as offshore wind and tidal power, will be reliant on, and therefore directly affect, the Great Lakes ecosystems. Areas that may be impacted by the turbines and transmission lines necessary to produce and transfer electricity include: benthic habitats and ecosystems; fisheries and other aquatic wildlife, including impacts resulting from excess noise, vibrations, and electromagnetism; shipwrecks and scuba diving; currents and ice formation; and recreational and commercial boating and fishing. So far, only Europe has built any offshore wind farms, and these are mainly located in saltwater ecosystems. This presentation will explore the lessons learned from the European experience and suggest what the region might expect from offshore wind development in the Great Lakes. This presentation will also identify the important environmental considerations that must be addressed as we move towards developing alternative energies in the basin. *Keywords: Environmental effects, Fish, Benthos.*

DOVE, A.¹ and WARREN, G.J.², ¹Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; ²USEPA Great Lakes National Program Office, 77 W. Jackson Blvd, Chicago, IL, 60604. **Long-Term Trends in Major Ions and Nutrients in Lake Ontario.**

Environment Canada's Surveillance Program and the USEPA Great Lakes Programs provide some of the most comprehensive information that is available worldwide for such a large lake. Environment Canada water quality data are used here to show the dramatic changes that have taken place over the last 40 years, with the early measurements indicating high phosphorus concentrations that were subsequently reduced by management actions. Some major ions showed reductions during the 1970s and 1980s as well. Nitrate has increased in the lake throughout the period of record, likely driven by increasing watershed and atmospheric sources. A major driver of more recent trends in water quality appears to be the invasion and subsequent expansion of invasive *Dreissena* mussel populations. The collective Canada and US water quality record shows that total phosphorus has further declined, but filtered P is showing a recent increase, possibly due to the filtering action of these mussels. Differences between the nearshore and

offshore illustrate this phenomenon. Concentrations of major ions that are incorporated in mussel shells such as calcium have declined, while those that do not, such as magnesium, have increased. Spring silica concentrations have increased to record levels, an ominous signal of declining diatom populations. *Keywords: Lake Ontario, Nutrients, Monitoring.*

DRAKE, D.A.R.¹, MANDRAK, N.E.², and HARVEY, H.H.¹, ¹Department of Ecology and Evolutionary Biology, University of Toronto, 25 Willcocks St., Toronto, ON, M5S 3B2; ²Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, 867 Lakeshore Rd., Burlington, ON, L7R 4A6. **Quantifying the Likelihood of Introducing Aquatic Invasive Species through the Baitfish Industry in Ontario.**

Aquatic invasive species (AIS) have negative impacts on the economic and ecological integrity of freshwater ecosystems, particularly within the Laurentian Great Lakes basin. Therefore, preventing further AIS introductions is of utmost importance. The commercial baitfish industry in Ontario is one of several secondary pathways that has the potential to transfer AIS within and beyond the Laurentian Great Lakes basin. Quantifying the relative risk posed by this pathway is a necessary first step to prioritize prevention management efforts. We quantitatively examined the risk of AIS introduction through the baitfish industry through harvesting in the wild, and subsequent release into the wild by the end user (i.e. the angler). We incorporated data from commercial harvest simulations, retail tank sampling, retail purchases, and end-user surveys to determine the likelihood of AIS occurrence within four key pathway uncertainties: 1) AIS encounter by commercial harvesters; 2) AIS occurrence within bait retailers; 3) AIS sale to end-users; and, 4) AIS release by end-users. Although the calculated overall probability of AIS introduction is low, the prevalence of bait-bucket release suggests that this pathway is an important transfer vector contingent upon the relative abundance of AIS within donor ecosystems and retail facilities. *Keywords: Invasive species, Fisheries, Risk assessment.*

DUNCAN, A.M.¹, GORR, M.W.², ROFKAR, J.R.², BARNSWELL, K.D.², GOTTGENS, J.F.¹, and DWYER, D.F.², ¹Dept. of Environmental Sciences, University of Toledo, Toledo, OH, 43606; ²Lake Erie Center, University of Toledo, Oregon, OH, 43618. **Plant-Mediated Reductions of Arsenic Levels in Flow-through Wetland Microcosms.**

Constructed wetlands are potentially an inexpensive means to remediate arsenic-contaminated water, a legacy of regional industries of the Great Lakes. We report here on using wetland microcosms to analyze arsenic uptake by three plant species. The microcosms were constructed of fiberglass troughs (58 x 17 x 13 cm) packed with a sandy loam soil ($\rho_b = 1.5 \text{ g cm}^{-3}$) for rooted plants, through which arsenic-containing water (1.5 mg As L^{-1} as Na_2HAsO_4) flowed. Water exited into plastic trays (20 x 20 x 6 cm) containing floating plants. Concentrations of arsenic are measured daily in soil and microcosm effluent, and weekly in plant tissues. In preliminary experiments using hydroponic systems, the rooted plant species, *Pycnanthemum virginianum* and *Spartina pectinata*, and the floating plant species, *Azolla caroliniana*, accumulated 327, 272, and 532 mg As kg^{-1} , respectively. Data obtained with these plants in the microcosms are being used both to determine the role of these plants in the uptake

of arsenic and complete a mass-balance for arsenic within the wetland ecosystem. The data will also be used to construct a computer model for sizing wetland systems for remediation of arsenic-contaminated water on a field-scale system. *Keywords: Wetlands, Pollutants, Microcosms.*

DUNLOP, E.S.¹, MILNE, S.W.², and RIDGWAY, M.S.¹, ¹Ontario Ministry of Natural Resources, 2140 East Bank Drive, Peterborough, ON, K9J 7B8; ²Milne Technologies, 91 Pinecrest Avenue, Keene, ON, K0J 2G0. **Temporal Trends in the Numbers and Characteristics of Lake Huron Fish Schools.**

We used fisheries acoustics to characterize the temporal dynamics of fish schools in Georgian Bay and the North Channel of Lake Huron from 2000-2004. Dramatic changes in fish school numbers and characteristics were observed over the 5-year period. Fish schools were observed to have an elongated shape that became narrower in height over time. There was also an increase in the distance of schools from bottom and a drop in the number of schools per km of transect, in the number and proportion of benthic schools, and in the depth, length, height, area, and volume of schools. Netting data confirms that there was a crash in alewife abundance that could explain the declines in the number of schools and the changes in fish school characteristics. There was also evidence that the alewife schools were replaced, to a degree, by lake herring schools in Georgian Bay and rainbow smelt schools in the North Channel. Our work provides an example of how fisheries acoustics can be used to study the spatial and behavioural dynamics of fish schools in the Great Lakes and contributes to a growing body of evidence of a recent regime shift in Lake Huron. *Keywords: Acoustics, Fish behavior, Lake Huron.*

DUSSAULT, E.B., MUIR, D.C.G., SHERRY, J.P., MCMASTER, M.E., and BROWN, S.B., Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **An Evaluation of the Health Status of Wild Fish from Wheatley Area of Concern - 2. PCB Body Burden and Hydroxylated Metabolites in Fish Plasma.**

Since the 1970s, Wheatley Harbour, located on the northwest shore of Lake Erie, has suffered from poor water quality due to industrial discharges, notably from fish and vegetable processing plants. Historical sources of PCBs in harbour sediments present a significant environmental concern, and thus have been the focus of several investigations. In addition to the risk posed by the presence of PCBs, studies have suggested that hydroxylated PCBs (OH-PCBs), by-products of microbial and biological degradation, could also interact with fish thyroid function. However, few studies to date have investigated the environmental exposure and effects of these metabolites in wild fish populations. The present study investigated the environmental occurrence of PCBs and hydroxylated metabolites in brown bullhead (*Ictalurus nebulosus*) from Wheatley Harbour Area of Concern. PCB congener body burdens were determined and plasma OH-PCBs concentrations were quantified using GC-high resolution mass spectrometry. PCBs and OH-PCB concentrations were greater in fish from Wheatley Harbour than in those from Hillman Marsh, a reference site. These results will be compared and contrasted with other site in the Great lakes, as well as measurements of fish health, in the context of potential environmental health effects. *Keywords: Fish, PCBs, Lake Erie.*

DUSSAULT, E.B., MCMASTER, M.E., PARROTT, J.L., SHERRY, J.P., and BROWN, S.B., Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6, Canada. **An Assessment of the Health Status of Wild Fish from Wheatley Harbour Area of Concern – 3. Multivariate Analyses.**

Despite the development over the past decades of several types of multivariate statistical analyses which could be applied to the interpretation of biological data, considerable resistance remains toward their regular application. In the present study, the applicability of Principal Component Analysis (PCA) for the analysis of fish health data from Wheatley Harbour was investigated, to determine whether the resulting principal components could successfully summarize and explain differences between exposed and reference sites. Health status data for brown bullhead (*Ictalurus nebulosus*) and goldfish (*Carassius auratus*) were analyzed in a series of PCAs, the first three components of which were retained for further analyses. General physiological characteristics were represented on the first principal component, while the second principal component was usually characterized by plasma measurements of steroid hormones and vitellogenin. Differences between sites were evaluated by multivariate analysis of variance, using the first three principal components as independent variables. The present study demonstrated that the use of PCA summarized complex data into a smaller number of variables, which explained relatively well the variability found within the dataset, and for which significant site differences were detected. *Keywords: Fish, Environmental contaminants, Lake Erie.*

DYBLE BRESSIE, J.¹, FAHNENSTIEL, G.L.¹, SARNELLE, O.², and VANDERPLOEG, H.A.¹, ¹NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48108; ²Michigan State University, Dept. of Fisheries and Wildlife, East Lansing, MI, 48824. **Assessing Environmental Controls on *Microcystis* Populations in the Great Lakes using Molecular Tools.**

Molecular tools have been employed with increasing frequency in the study of harmful algal bloom (HAB) species. However, not all tools and techniques can be employed equally. For example, the gene targets that are useful for differentiating populations generally are not the same as those that should be used for detecting cells in environmental samples. We will discuss the use of various molecular approaches to better understand *Microcystis* ecology, physiology, population dynamics and toxicity in the Great Lakes. This will include the use of phylogenetic analysis of functional vs. non-coding gene regions, gene expression studies to identify the environmental conditions that regulate toxin production and quantitative PCR assays for addressing the impacts of dreissenid mussels on *Microcystis* populations. *Keywords: Harmful algal blooms, Genetics, Microcystis.*

EBERHARDT, R.A., Michigan Office of the Great Lakes, P.O. Box 30473, Lansing, MI, 48909. **The Lake Superior Aquatic Invasive Species Complete Prevention Plan.**

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

A plan for prevention of new introductions of aquatic invasive species to Lake Superior is under development using the Lake Superior Lakewide Management Plan structure. The plan is using a vector/pathway approach to prevention and is binational in approach. The presentation describes the opportunities and challenges that exist for prevention of new invasives to Lake Superior and the value of using the binational Lakewide Management Plan mechanism for development of the plan. *Keywords: Invasive species, Lake Superior.*

EDWARDS, W.J.¹, CONROY, J.D.², and THOMAS, M.A.³, ¹Department of Biology, DePaul Hall, Niagara University, NY, 14109; ²Aquatic Ecology Laboratory, Department of Evolution Ecology and Organismal Biology, The Ohio State University, 1314 Kinnear Rd., Columbus, OH, 43212; ³F.T. Stone Laboratory, The Ohio State University, 1314 Kinnear Rd., Area 100, Columbus, OH, 43212. **Assessment of Metabolism in a Coupled Nearshore-Offshore Ecosystem in Lake Erie.**

Recent research indicates that many small lakes are net heterotrophic, supplied with reduced carbon from terrestrial runoff. However, large lakes may be net autotrophic due to relatively less reduced carbon input as a function of lake size and also nearshore processing of reduced. We investigated this hypothesis by determining whole-lake metabolism for the Sandusky Bay-Lake Erie system. Whole-lake metabolism was estimated using continuous and synoptic measurements of temperature, dissolved oxygen concentrations, chlorophyll a concentrations, turbidity, and wind speeds along a transect from the Sandusky River, through Sandusky Bay, and offshore into the Sandusky subbasin of Lake Erie. Preliminary results indicate net autotrophy in both the river and bay during most of the summer. However, offshore sites were net heterotrophic in late summer, despite high gross primary productivity. Late-summer heterotrophy corresponded to offshore hypolimnetic anoxia, indicating that nearshore-produced phytoplankton (where chlorophyll a concentrations exceeded 50 mg/m³) may be directly exported into the hypolimnion. These results indicate that watershed nutrient controls may be less effective on offshore oxygen and phytoplankton dynamics during the late summer when oxygen depletion effects are most critical and hypoxia becomes problematic.

Keywords: Productivity, Lake Erie, Metabolism.

EDWARDS, W.J.¹, ATKINSON, J.F.², THOMAS, S.P.³, PAVLAC, M.M.³, BOYER, G.L.³, PENNUTO, C.M.⁴, BASILIKO, C.⁴, CLAPSADL, M.⁴, LEWIS, T.W.⁵, and MAKAREWICZ, J.C.⁵, ¹Department of Biology, Niagara University, Lewiston, NY, 14109; ²Great Lakes Program, SUNY at Buffalo, 202 Jarvis Hall, Buffalo, NY, 14260; ³Department of Chemistry, SUNY-ESF, 1 Forestry Drive, Syracuse, NY, 13210; ⁴Great Lakes Center, Buffalo State College, 1300 Elmwood Ave., Buffalo, NY, 14222; ⁵Department of Environmental Science and Biology, SUNY-Brockport, 125 Lennon Hall, Brockport, NY, 14420. **Lake Ontario Nearshore Nutrient Transport Study (LONNS): Hydrodynamics of the Nearshore Region.**

The Lake Ontario Nearshore Nutrient Transport Study (LONNS) was implemented in 2008 to assess the inadequacy of phosphorus models in predicting Lake Ontario ecosystem changes. The LONNS assessed the decoupling of the offshore where nutrient levels have fallen and water clarity increased and the nearshore environments where phosphorus levels have

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

increased and nuisance blooms of *Cladophora* have become important. We assess whether a change in the offshore movement of P is caused by sequestration in the nearshore. Water velocity fields were measured using an Acoustic Doppler Profiler and mapped in a GIS. Concurrent measurements were taken of temperature, phytoplankton (fluoroprobe), nutrients, and turbidity across a series of transect perpendicular to the shore around the mouths of three tributaries of Lake Ontario: Sandy Creek, Oak Orchard Creek. We assess the importance of physical processes in the nearshore-offshore decoupling, including the presence of spring thermal bars, later hypolimnetic upwelling and the prevailing coastal flow regime. *Keywords: Hydrodynamics, Lake Ontario, Nutrients.*

EGAN, K.J., University of Toledo, Toledo, OH, 43606. **Environmental Economics.**

Since the environmental issues we face today are the result of human economic activity, environmental economics plays a key role in explaining why the environmental issues arise. And more importantly, the field of environmental economics points out economic policies that, if implemented, will change households and firms incentives so that the environmental issues are mitigated. The major obstacle is that economic markets ignore generated pollution and environmental degradation. I will discuss several examples of applied environmental economic research that values environmental goods such as water quality, so that these public goods are considered by policymakers along with the usual marketed activities. I will also discuss curriculum structure for environmental economics that best suites those students who will find employment in the environmental job market. *Keywords: Economic evaluation, Education.*

EGLITE, E. and MANLEY, T.O., Middlebury College, Dept. of Geology, Middlebury, VT, 5753, USA. **Cirulation Dynamics of St. Albans Bay, Lake Champlain.**

Since the 1960's, St. Albans Bay has experienced significant alteration in its aquatic ecosystem due to prevalence of an algae-dominated environment. Extensive Cyanobacteria blooms are a severe response to continuous influx of phosphorus (P) from runoff. It is believed that poor circulation, especially applicable to the inner bay, limits water exchange and the P concentration increases over time. In this region, the algal blooms have caused significant property value depreciation, losses in tourism industry and more importantly health concerns. Mechanisms for increased primary productivity of algae depend on physical and geochemical parameters such as transparency, temperature, acidity, nutrient loading, oxygen abundance, nitrogen-P ratios and currents. None of the previous studies have considered the effects of hydrodynamics in their results. In 2007, 13 moorings collected over 1.2 million observations which were later melded with wind data. Preliminary findings show an average counterclockwise circulation in the inner and outer bays along with strong oscillatory circulation (1.7-3.5 d) linked to the larger Inland Sea. In the outer bay, there is a component of northward flow through the Ball Island and Burton Island passages. There appear to be phases of inflow of hypolimnetic water from Inland Sea that also flood the inner bay. *Keywords: Hydrodynamics, Water quality, Eutrophication.*

EMMENEGGER, E.¹, KURATH, G.¹, BINKOWSKI, F.², and GOETZ, R.², ¹USGS, Western Fisheries Research Center, 6505 NE 65th St., Seattle, WA, 98115; ²UWM-Great Lakes WATER Institute, 600 E. Greenfield Ave., Milwaukee, WI, 53204. **Yellow Perch (*Perca flavescens*) Susceptibility to Viral Hemorrhagic Septicemia Virus Isolates from Europe and North America.**

The recent emergence of viral hemorrhagic septicemia virus (VHSV) in the Great Lakes region of North America has led to dramatic multi-species epidemics, and the virus has been isolated from over 25 Great Lakes fish species. Yellow perch (*Perca flavescens*) is an important freshwater aquaculture and natural resource species that has experienced high mortality due to VHSV in the Great Lakes. Availability of pathogen-free stocks of cultured yellow perch facilitates its development as a model for wetlab studies of VHSV infection and virulence. In pilot virulence trials we have challenged yellow perch by injection with three strains of VHSV from the Great Lakes, the North American west coast, and Europe. These strains represent VHSV genotype groups IVb, IVa, and I, respectively. All three strains cause high mortality under these conditions, with no difference between susceptibility to the IVa and IVb strains. These results have relevance to management of VHSV in the Great Lakes, and demonstrate that yellow perch can be used as a positive control species in an aquatic biosafety level three (BSL-3) laboratory challenge model for the Great Lakes VHSV studies. *Keywords: Fish diseases, Yellow perch.*

ENGEVOLD, P.M., SANDGREN, C.D., and BERGES, J.A., University of Wisconsin - Milwaukee, Department of Biological Sciences, Milwaukee, WI, 53211. **Changes in Phytoplankton Particulate C:N:P Composition in Response to Nutrient Enrichment and Manipulations of Natural Herbivore Abundance in Lake Michigan During Summer 2008.**

The impact of nutrients and herbivory on algal C:N:P was investigated using herbivore gradient experiments set up on six summer 2008 cruises visiting nearshore (20m) and offshore (100m) stations. Epilimnetic water was screened free of macrozooplankton. Net-collected animals were then added to create an artificial gradient of 0X to approximately 6X ambient animal abundance in 8L bottles. Additional 0X and 1X bottles were enriched with N, P and Si to saturate cellular quotas. Bottles were incubated in a water-jacketed plankton wheel for 4-5 days at near ambient epilimnetic light and temperature. Algal molar C:N:P was determined by wet oxidation (PP) and CN analyzer. Particulate molar ratios for nutrient-replete algae in enriched treatments were consistently: C:N = 7-10, C:P = 50-70. At both stations, C:N ratios without enrichment were similar to the replete ratios and were not affected by changing herbivore abundance on any cruise. Nearshore and offshore phytoplankton C:P ratios without enrichment were in the range of 125-175 and 150-200, respectively. C:P ratios increased by roughly 25% when herbivores were removed and progressively decreased with increasing animal abundance. P is consistently the limiting nutrient at both stations. Increasing herbivore abundance results in P enrichment of the algae not consumed. *Keywords: Phytoplankton, Lake Michigan, Nutrients.*

ENGEVOLD, P.M., SANDREN, C.D., and BERGES, J.A., University of Wisconsin - Milwaukee, Department of Biological Sciences, Milwaukee, WI, 53211. **Changes in**

Phytoplankton Photosynthetic Parameters P_{max} and Alpha in Response to Nutrient Enrichment and Manipulations of Natural Herbivore Abundance in Lake Michigan during Summer 2008.

The impact of nutrients and herbivory on algal primary production was investigated using herbivore gradient experiments set up on summer 2008 cruises visiting both nearshore (20m) and offshore (100m) stations. Epilimnetic water was screened free of macrozooplankton and net-collected animals were then added to create an artificial gradient of 0X to 6X ambient animal abundance in 8L bottles. Bottles with 0X and 1X macrozooplankton were enriched with N, P and Si to saturate cellular quotas. Bottles were incubated in a water-jacketed plankton wheel for 4-5 days at near ambient epilimnetic light and temperature. P vs I curves were developed for each bottle using a photosynthetron and ¹⁴C-bicarbonate; estimates of P_{max} and alpha were obtained from a hyperbolic-tangent curve fit. Nutrient enrichment resulted in 2-3X & 4-8X increases in both parameters at the offshore and nearshore stations, respectively. Consequent I_K values were not changed by enrichment offshore, but approximately doubled nearshore. Herbivore abundance had no effect on P_{max} and alpha nearshore. Offshore, increasing herbivores resulted in reduced gross production but increased biomass-specific production rates during July and August, signaling the importance to the algae of herbivore-mediated nutrient remineralization.

Keywords: Lake Michigan, Photosynthesis, Phytoplankton.

ESTENIK, J.¹, HALE, S.², SHASKUS, M.¹, and SMITH, M.¹, ¹Ohio EPA - Division of Surface Water, 50 W. Town St. Suite 700, Columbus, OH, 43215; ²ODNR - Division of Wildlife, 2045 Morse Rd., Building G-3, Columbus, OH, 43229. **Ohio's Sport Fish Consumption Advisory.**

Ohio began issuing public health advice about consuming sport fish in 1983. Since that time, Ohio has annually collected and analyzed fish for contaminants including PCBs, mercury, and organochlorine pesticides. Sportfish consumption advisories were initially focused on highly contaminated surface waters, sediment, and fish. Since 1993 contaminant levels have been evaluated using risk assessment methods and synthesized into advisories about how often to consume fish from specific locations in Ohio. The risk assessment methods used to generate these advisories are based primarily upon the "Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory", (September 1993) and its subsequent addenda. The Protocol is used as the basis for fish consumption advisories throughout the Great Lakes states. Ohio's advice is distributed to the public through printed materials, news media, and online. Information is targeted to anglers, due to consumption frequency, and to pregnant women and women with small children, due to greater susceptibility to contaminant effects. *Keywords: Risk assessment, Bioaccumulation, Fish toxins.*

EVANS, L.E., 77 W. Jackson Blvd, Chicago, IL, 60442. **Botulism Network.**

ABSTRACT SUBMISSION: Discuss the US EPA's involvement in current Botulism issues. More specifically, EPA is aware that the Type E botulism outbreaks and the related widespread die-offs of fish and birds are a recurring problem in the Laurentian Great Lakes basin. There is therefore a pressing need to identify management actions for the control of

botulism to potentially mitigate the impacts of these outbreaks. To this end, an invitational meeting of leading botulism researchers and agency representatives was convened to foster collaboration and generate new ideas. Invitees were asked to investigate the feasibility of management actions in light of the state of current knowledge of the botulism issue in the Great Lakes. The workshop was sponsored by the Great Lakes Interagency Task Force's Regional Working Group.

EVANS, M.A.¹, YOSHIYAMA, K.², KLAUSMEIER, C.A.¹, and LITCHMAN, E.¹, ¹W. K. Kellogg Biological Station, Michigan State University, Hickory Corners, MI, 49060; ²Department of Chemical Oceanography, Ocean Research Institute, University of Tokyo, Tokyo, Japan. **Climate Driven Variability in *Microcystis* Abundance, Dominance, and Toxin Production.**

Examining inter-annual variability is a useful method for determining the potential impact of climate change. *Microcystis* and other harmful cyanobacteria are known to be sensitive to climate drivers, especially through impacts on water temperature and stratification. However, prior studies focused on major weather anomalies (such as a heat-wave) and their impact on HABs. In a multi-year study of phytoplankton abundances in Gull Lake, MI (USA) we found that slight differences in weather drivers may lead to substantial differences in algal community composition and especially in *Microcystis* abundance. Near Gull Lake, 2008 was a cooler year than 2007, but air temperature differences were small (<1 °C average difference in mean daily temperature). This led to slightly cooler surface waters (average summer temperature 23.7 vs. 24.3 °C) and increased surface mixing in 2008. As a result of these small changes in drivers, in 2008 small *Microcystis* colonies decreased 4-fold in abundance (from $3.3 \times 10^5 \mu\text{m}^3 \text{ml}^{-1}$ in 2007), and larger *Microcystis* colonies became undetectable, compared to a peak abundance of $1.2 \times 10^5 \mu\text{m}^3 \text{ml}^{-1}$ in 2007. Abundance of other species increased in 2008 and microcystin decreased along with *Microcystis*. *Keywords: Harmful algal blooms, Climate change, Microcystis.*

EVANS, M.S.¹, MUIR, D.C.G.², KEATING, J.¹, and WANG, X.², ¹Environment Canada, 11 Innovation Boulevard, Saskatoon, SK, S7N 3H5; ²Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Metals and Organic Contaminants in Lake Trout and Burbot from Great Slave Lake, Northwest Territories over 1993-2007: Spatial and Temporal Patterns.**

We have been monitoring contaminants in lake trout and burbot from Great Slave Lake since the early 1990s as part of the Northern Contaminants Program. The majority of contaminants are believed to enter the lake through long-range atmospheric transport with the Slave River regionally important. Fish, which are caught from the East Arm and West Basin, are analyzed for a variety of organic contaminants and metals in addition to length, weight, sex, age, lipid, and carbon and nitrogen isotopes being determined. Fish differ in their growth characteristics and, to a lesser extent, feeding, in the two regions of the lake. Some organochlorine contaminants such as HCH are showing evidence of a decline while others such as PCBs are showing little change. Mercury concentrations are showing a trend of increase. There is some evidence that changing lipid concentrations and feeding patterns may be driving

and/or modifying these contaminant trends. In addition, some contaminant trends may be related to a warming trend (e.g., mercury) while other trends may be in response to reduced contaminant use and an absolute reduction of these contaminants circulating in the environment (e.g., HCH, PFOS and PFSA). The influences of the Slave River on contaminant patterns and the biology of burbot and lake trout are briefly discussed.

EVANS, M.S.¹, DAVIS, M.², DE BOER, D.³, MCEACHERN, P.⁴, KEATING, J.¹, and LOCKHART, W.L.⁵, ¹Environment Canada, Saskatoon, SK; ²Hatfield Consultants, West Vancouver, BC; ³University of Saskatchewan, Saskatoon, SK; ⁴Alberta Environment, Edmonton, AB; ⁵833 Harstone Rd., Winnipeg, MB. **PAH Sediment Studies in Lake Athabasca and the Athabasca River Ecosystem: Natural Sources and the Impacts of Oil Sands Development.**

The Mackenzie River Basin is rich in hydrocarbon reserves with mining activity intensifying with the expansion of oil sands operations in the Fort McMurray area and the proposed expansion of gas extraction in the Beaufort Sea, Mackenzie River delta and surrounding area. Thus, there is much interest in presence of hydrocarbons such as polycyclic aromatic hydrocarbons (PAHs) in the environment, their sources, and the impact of industry in modifying concentrations in downstream delta and lake ecosystems. Here we report on our characterization of PAH sources and composition in the Lake Athabasca, and the Peace-Athabasca delta, and the implications to Great Slave Lake and Mackenzie River deltas. Natural petrogenic sources are numerous along the Athabasca and Peace rivers; thus, compounds of petrogenic origin dominate in tributary and downstream sediments. In the Athabasca River basin, highest PAH concentrations are associated with locations near exposed bitumen beds and secondarily with fine-grained sediments in the tributaries and in downstream depositional areas. Concentrations of some low molecular weight PAHs exceed interim sediment quality guidelines in the delta and Lake Athabasca. Temporal trends in PAH concentrations in Athabasca sediment cores appear to be related to hydrological change

FAHNENSTIEL, G.L.¹, POTHOVEN, S.A.¹, VANDERPLOEG, H.A.¹, KLARER, D.M.², NALEPA, T.F.¹, and SCAVIA, D.³, ¹Great Lakes Env. Res. Lab/NOAA, 4840 S. State Rd, Ann Arbor, MI, 48108; ²Old Woman Creek Nat. Res. Res., Huron, OH, 44839; ³School of Nat. Res. Env, Univ. Michigan, Ann Arbor, MI, 48105. **Long-term Trends in Phytoplankton Abundance, Composition and Primary Production in the Offshore Region of Southeastern Lake Michigan.**

Since 1973 sampling has been conducted in the offshore region of southeastern Lake Michigan (off Grand Haven/Muskegon). Extensive monitoring in this region began in the early 1980s and has continued through 2008. This monitoring has included a variety of water quality and lower food web parameters. In this poster we present information on phytoplankton abundance (chlorophyll a) composition, and primary production (both volumetric and areal integrated). The Great Lakes Production model (similar to Fee model) was used to estimate phytoplankton primary production. During the past twenty-five years significant changes in phytoplankton abundance, composition and areal primary production have been observed with the most significant changes occurring in the last five years. Most of these changes in the

offshore pelagic region can be attributed to filtering activities of dreissinid mussels.

Keywords: Invasive species, Mussels, Photosynthesis.

FAISAL, M., GUNN, M., SCHULTZ, C., WINTERS, A., KIM, R., and MILLARD, E., College of Veterinary Medicine, Michigan State University, East Lansing, MI, 48824. **Emergence and Spread of Viral Hemorrhagic Septicemia Virus in the Laurentian Great Lakes.**

In 2003, VHSV invaded the Great Lakes and was first isolated from muskellunge in Lake St. Clair, MI. By 2008, VHSV has spread into four of the Great Lakes and a number of inland lakes. Phylogenetic analysis demonstrated that the Great Lakes VHSV strain is a unique sublineage of VHSV genotype IV (designated IVb). This is the first time in which VHSV, believed to be of marine origin, became so widespread in a freshwater system devastating a wide range of fish species. Designing effective control strategies requires a thorough knowledge of the disease ecology, carriers, and virus reservoir in particular. Over the past years, our laboratory tested key fish species from the Great lakes, streams, and inland lakes for the presence of VHSV and/or its circulating antibodies. In addition, a number of invertebrates that live in close proximity to susceptible fish species were also analyzed for the presence of VHSV. Data collected demonstrated that the virus became endemic in certain sites within the Great lakes basin. Fish living in these sites are continuously exposed to VHSV and some can survive the infection. VHSV was also present in relatively high prevalence in two invertebrate species. Whether or not invertebrates play a role as a carrier or reservoir of infection remains to be elucidated. *Keywords: Exotic species, Reservoirs, Fish.*

FENICHEL, E.P.¹, TSAO, J.I.², JONES, M.L.², and HICKLING, G.J.³, ¹Arizona State University, School of Life Science, Tempe, AZ, 85287; ²Michigan State University, Dept. of Fisheries and Wildlife, East Lansing, MI, 48824; ³University of Tennessee, Dept. of Forestry, Wildlife, and Fisheries, Knoxville, TN, 37996. **Risks are Not Always What They Seem, the Case of Sterile Male Sea Lamprey Transfers.**

Recently, an adaptation of the method of real options analysis (ROA) was proposed as a way to calculate a precautionary multiplier and implement the precautionary approach to fisheries management. The ROA framework focuses on 3 issues associated with managing fishery risk: (1) To some extent, risk is a function of management behavior. It is this component of risk that managers should be concerned with when evaluating a decision, and not the overall uncertainty in the system. (2) Fishery management involves irreversible events. There is value in maintaining opportunities and putting off irreversible decisions (or decisions that lead to irreversible events). (3) Risk involves the probability of loss for people through the fishery, and therefore risk can only be evaluated within the context of the value of the services to people from the fishery. We use the ROA framework to analyze the decision to move sea lamprey, and potentially aquatic pathogens, from Lake Ontario to the St. Marys River (Lake Huron), as part of the sterile male release program for invasive sea lamprey control. ROA helps separate the risk associated with the decision from broader uncertainty. ROA's approach to integrated risk analysis and risk management indicates that the risks associated with this decision may be more

complex than previously thought. *Keywords: Decision making, St. Marys River, Invasive species.*

FETZER, W.W., WEST, D.C., WHITE, K.E., FORNEY, J.L., JACKSON, J.R., RUDSTAM, L.G., BROOKING, T.E., and VANDEVALK, A.J., Cornell Biological Field Station, 900 Shackelton Point Road, Bridgeport, NY, 13030, USA. **Evaluating Young-of-the-Year Yellow Perch (*Perca flavescens*) Response to Habitat Changes Following Zebra Mussel (*Dreissena polymorpha*) Introduction in Oneida Lake, NY.**

Changes in the abundance and quality of habitat types can alter population dynamics of species with habitat-specific demographic rates. Zebra mussel introductions are a well-known example of a non-native species that has altered the ecology and heterogeneity of aquatic ecosystems. Irwin et al. (2007) assessed the effect of mussel introduction and other perturbations on young-of-the-year (YOY) yellow perch dynamics in Oneida Lake, NY, observing reduced abundance across all early life stages, increased mortality from the pelagic to demersal stage, and decreased mortality throughout the demersal stage. Interestingly, YOY mortality attributed to walleye predation has decreased from 91.7% to 49.3% following zebra mussel invasion. YOY are increasingly selecting littoral habitats, and the percent of autumn catch from shallow sites in the CBFS long-term sampling has increased from 51% pre-zebra mussel invasion (1964-1990) to 74% post-invasion (1991-2006). We suggest changes in YOY habitat selection as an alternative explanation for observed changes in abundance and mortality rates. Results from Oneida Lake can be informative throughout the Great Lakes basin, highlighting the complexity of species responses to invasive species and the importance of exploring alternative explanations to patterns observed through long-term monitoring. *Keywords: Percids, Spatial distribution, Zebra mussels.*

FILLINGHAM, J.H., BOOTSMA, H.A., and ROEBBER, P.J., University of Wisconsin Milwaukee, 2200 E Kenwood Blvd, P.O. Box 413, Milwaukee, WI, 53201. **Modeling Waves and their Influence on Air-Water Gas Exchange in Lake Michigan.**

The accuracy of a Great Lakes wind-wave forecasting model, currently used by the Great Lakes Coastal Forecasting System, is tested using measured wave data from a buoy site in the coastal zone of Lake Michigan. The study uses UWM Mesoscale Meteorological Model hindcasting simulations as input for the wave model analysis. A complete wave height and period data set was collected from October 10, 2008 to November 3, 2008 using an Acoustic Doppler Current Profiler/Wave Gauge. Air temperature, wind, humidity, and barometric pressure data were collected during the same period from monitoring equipment on the buoy itself. It is expected that the accuracy of wave forecasting on Lake Michigan will be improved through the implementation of a mesoscale meteorological model, as wave model input. Wave data collection and analysis is ultimately critical to CO₂ gas exchange studies continuing at the same buoy site, and across Lake Michigan, due to the direct dependence of gas transfer on subsurface turbulence generated by wind-wave dynamics. This presentation will provide an analysis of the wind-wave relationship for the near shore zone, the potential influence of this relationship on the gas transfer coefficient, and the potential error in CO₂ flux estimates resulting from different gas transfer coefficient models. *Keywords: Atmosphere-lake interaction, Carbon, Waves.*

FINLAYSON, P.H.¹, HYDE, R.D.¹, STADLER-SALT, N.², and BERTRAM, P.³, ¹Environment Canada, 4905 Dufferin St., Toronto, ON, M3H 5T4; ²Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; ³U.S. Environmental Protection Agency, 77 W. Jackson Boulevard (G-17J), Chicago, IL, 60604-3511. **State of the Great Lakes Basin Ecosystem 2008.**

As parties to the Great Lakes Water Quality Agreement, the governments of Canada and the United States are responsible for accurate reporting on the state of the Great Lakes. The State of the Lakes Ecosystem Conference (SOLEC), first held in 1994 and most recently in 2008, is a result of this commitment. With the establishment of a consistent suite of ecosystem indicators, the health of the Great Lakes basin can be objectively assessed. Regular reporting using a core set of indicators promotes more efficient and successful management, as well as creates more accessible information for decision makers and the public. For SOLEC 2008, indicator reports including status and trends were prepared for 63 of the more than 80 indicators currently in the Great Lakes suite. In addition to individual analysis, indicators were grouped into nine categories that were also assessed for status and trend: contamination, biotic communities, invasive species, coastal zones, aquatic habitats, human health, land use-land cover, resource utilization and climate change. The overall status of the Great Lakes ecosystem was assessed as mixed because some conditions or areas were good while others were poor. The trends of Great Lakes ecosystem conditions varied: some conditions were improving and some were worsening.

Keywords: Indicators, Great Lakes basin, Regional analysis.

FISHER, T.G., Dept. Environmental Sciences, University of Toledo, Toledo, OH, 43606.
Glacial Evolution of the Great Lakes Region.

The history of plant colonization and succession in the Great Lakes basins has its beginnings with the events of the last ice age. These basins themselves owe their origins to primarily glacial processes during numerous glaciations during the Quaternary period; extending back in time approximately 2 million years. Recession of glacial lobes within their respective basins was characterized by numerous readvances and still stands, resulting in the formation of moraines and sand and gravel outwash plains. With drainage to lower outlets to the northeast blocked by the receding ice mass, large proglacial lakes developed in each of the modern lake basins, which were at times connected with each other, but ultimately overflowed drainage divides, draining southwards into the Mississippi River system. It is during these times that high elevation beaches formed in the basins, and lake outflow was channelized, forming deep valleys. The time it took for ice to finally recede from the Great Lakes basins is roughly equivalent to the time that they have remained ice free. During the last ~11,000 years lake levels have fluctuated significantly; by nearly 100 m in the Lake Michigan basin alone. These fluctuations are primarily in response to geophysical processes, with past episodes of climate change playing a minor role. In summary, the origin *Keywords: Great Lakes basin.*

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

FLANAGAN, M.M., Joyce Foundation, 70 W Madison St Suite 2750, Chicago, IL, 60602.

Watershed Restoration in the Maumee Basin.

In 2007 The Chicago-based Joyce Foundation awarded \$5 million in grants to a total of four national and local organizations in a quest to aid the recovery of the Maumee watershed. Environmental Defense will work to expand and target agricultural conservation incentives available to farmers. The Nature Conservancy will enlist Indiana farmers to test an improved design for drainage ditches that, in initial tests, dramatically reduced sediment and improved water quality entering local streams; further downstream, TNC will seek to reduce runoff from expanding suburban developments by restoring wetlands in the ecologically rich Oak Openings area and in creating a “green ribbon” along the lower Maumee River. Partners for Clean Streams Inc. will test strategies for reversing ecological damage from a dam structure on Swan Creek in Toledo, complete risk assessments for Duck Creek and Otter Creek, and create inventory and restoration plans for the Swan Creek and the Ottawa River. American Rivers will work with local government and residents in Toledo to capture and filter storm water in gardens, rain barrels, wetlands, and other forms of “green infrastructure” and keep it out of the sewer system, thus reducing floods and sewage overflows into the river and Lake Erie. *Keywords: Watersheds, Management, Ecosystems.*

FLORENCE, L.W.¹ and ZINT, M.T.², ¹Cooperative Institute for Limnology and Ecosystems Research, 440 Church St., Ann Arbor, MI, 48109; ²University of Michigan School of Natural Resources and Environment, 440 Church St., Ann Arbor, MI, 48109. **National Ocean Sciences Bowl: Using MEERA to Evaluate an Established Environmental Education Program.**

The Great Lakes Bowl is a regional competition of the National Ocean Sciences Bowl (NOSB), an academic competition that tests high school students’ knowledge of Great Lakes and ocean sciences. After 10 years of hosting the Great Lakes Bowl, we wanted to evaluate and improve key aspects of the program. The goal of the evaluation was to identify how current teachers became involved in NOSB, what aspects of the program encourage them to maintain their participation, and to determine effective ways of promoting NOSB and increasing the number of schools that compete. The evaluation was designed and implemented with the assistance of MEERA, a web-based resource that supports evaluation of environmental education programs. The evaluation process included the development of a logic model, setting goals and indicators, survey design and implementation, analysis, reporting, and program improvement. The evaluation was conducted in-house with a small staff, and demonstrates how MEERA can be used by educators with limited or no previous evaluation experience. *Keywords: Education, Evaluation.*

FOCHT, W.J.¹, VINCENT, S.G.¹, and BLOCKSTEIN, D.E.², ¹Oklahoma State University, 003 Life Sciences East, Stillwater, OK, 74078-3011, United States; ²Council of Environmental Deans and Directors, 1101 17th St, NW #250, Washington, DC, 20036, United States. **Environmental Curricula in Higher Education: Exploring Common Ground.**

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

Interdisciplinary environmental programs have proliferated and flourished in higher educational institutions across the United States for four decades. Despite this long history and the large and growing number of programs, no consensus has emerged on a shared program identity or core principles. The Council of Environmental Deans and Directors (CEDD) organized by the National Council for Science and the Environment is the leading organization working to improve the quality, stature and effectiveness of interdisciplinary environmental programs on the nation's campuses. There have been 30 years of active experimentation in environmental programs and curricula. More than 600 degree-granting interdisciplinary programs focus on the environment and sustainability. Through CEDD, NCSE has brought together the leaders of many of these programs, to assess their history and shape a common future. We are engaged in the first systematic attempt to bring together what these programs have learned, identify emergent qualities of the field and collectively set new directions. Our research indicates that sustainability is emerging as a guiding paradigm for the field but there is great diversity among programs in emphasis and practice. See www.ncseonline.org/CEDD.

Keywords: Environmental education, Environmental curriculum, Environmental science and studies.

FORTNER, R.W., COSEE Great Lakes, 113 Paula Circle, Oak Island, NC, 28465. **Reaching Hundreds with Online Great Lakes Workshops.**

Each year, COSEE Great Lakes produces a free online workshop with the assistance of The College of Exploration. Topics to date have been "What's so great about the Great Lakes?", "The Great Lakes ROCK!", and "Great Lakes Alive." The programs provide narrated slide shows by prominent scientists, classroom materials and Internet resources on each presentation, a conversation "café," and real-time discussion among participants and presenters. Each year's workshop has attracted 200-400 participants, demonstrating the effectiveness of this model for reaching large numbers of individuals with research information. The session will review format and development considerations, participant demographics, and producers' research on program effects. *Keywords: Education, Outreach, Technology.*

FRANCIS, J.T., 26000 W. Eight Mile Rd, MDNR-Fisheries, Southfield, MI, 48034.

Characterization of the Nearshore Fish Community in the Huron-Erie Corridor.

The nearshore fish community was sampled in western Lake Erie in 2005, the lower Detroit River in 2006 and 2008, and the St. Clair Flats in 2007. A combination of electrofishing, fyke netting, and beach seines were used to target a variety of habitat types in the nearshore waters. The combined catch included 66 species of fish from 19 families. This survey documents the great variety of fish species that rely on nearshore habitat in this system for at least some stage of their life cycle. Nearshore habitat has been shown to be particularly important for juvenile game fish and forage fish production. The completion of this study provides important baseline data on the fish community in the Huron-Erie Corridor. *Keywords: Fish, Coastal wetlands, Detroit River.*

FUGATE, E.J. and ZIMMERMAN, J.B., 9 Hillhouse Ave., Rm 227, New Haven, CT, 6511.
System Dynamics Modeling of Water Resources.

System dynamics (SD) modeling provides a format for describing, analyzing, and investigating the complex systems and processes. SD can be used to assess water resources within a watershed under current and future conditions including environmental, social, political, and market mechanisms. This provides insight into system behavior, enables the simulation of complex future scenarios, and highlights leverage points for sustainability. In this critical review, we consider previous uses of system dynamics in water resource applications and other relevant areas and highlight knowledge gaps that could potentially hinder the implementation of this methodology. Based on this review, we present a general framework for representing the relevant systems and feedback loops associated with water quality and quantity within a Great Lakes watershed. *Keywords: Climate change, Watersheds, Model studies.*

GADEN, M.¹, EBERHARDT, R.A.², BUCHSBAUM, A.³, MURRAY, M.³, and GRUBB, C.³,
¹Great Lakes Fishery Commission, Ann Arbor, MI; ²Michigan Office of the Great Lakes, Lansing, MI; ³Healing our Waters Coalition, National Wildlife Federation, Ann Arbor, MI. **The Great Lakes Regional Collaboration: A New Paradigm for Restoring Ecosystem Health?**

In December, 2005, the United States EPA-led Federal Interagency Task Force officially released the Great Lakes Regional Collaboration Strategy to Restore and Protect the Great Lakes. The strategy provided specific recommendations for action and was the product of the Great Lakes Regional Collaboration, convened pursuant to an executive order issued by President Bush in 2004. Beyond leading to the development of a restoration strategy, the executive order also called for increased collaboration among federal cabinet secretaries responsible for Great Lakes programs and to create new or strengthened relationships among government officials and stakeholders. All told, the strategy was the result collaboration among thousands of participants interested in restoring the Great Lakes, with involvement from government (federal, state, local, and intergovernmental bodies), industry, tribes, nongovernmental organizations, and the general public. More than three years have elapsed since the release of the strategy. This paper outlines the Collaboration process and intent, describes the product of the collaboration, summarizes efforts and progress to implement the strategy, and offers observations on whether the Collaboration represents an appropriate new paradigm for restoring ecosystem health.

Keywords: Policy making, Political aspects, Ecosystem health.

GALARNEAU, E.¹, MAKAR, P.A.¹, and DIAMOND, M.L.², ¹Air Quality Research Division, Environment Canada, 4905 Dufferin Street, Toronto, ON, M3H 5T4; ²Dept. of Geography, University of Toronto, 45 St. George Street, Toronto, ON, M5S 3G3. **Air Quality Modelling of PAHs in the Great Lakes Basin.**

Polycyclic aromatic hydrocarbons (PAHs) are toxic contaminants subject to regional and long-range atmospheric transport. Environment Canada's regional air quality model, AURAMS, was originally developed to study issues relating to ground-level ozone and particulate matter, but has recently been modified to account for the processes specific to semivolatile toxic

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

contaminants such as PAHs. In this presentation, model results using AURAMS-PAH will be compared to measurement data from the Great Lakes Basin with an emphasis on relating simulation quality to atmospheric conditions, geographic location and process representations in the model. *Keywords: PAHs, Air quality model, Particle/gas partitioning.*

GALARNEAU, E.¹ and HOLSEN, T.M.², ¹Air Quality Research Division, Environment Canada, 4905 Dufferin Street, Toronto, ON, M3H 5T4; ²Department of Civil and Environmental Engineering, Clarkson University, 8 Clarkson Avenue, Potsdam, NY, 13699. **Making the Deposition of Airborne Toxic Substances a Threat of the Past: An Interactive Panel Discussion.**

Over twenty years have passed since Canada and the U.S. committed to conducting research, surveillance and monitoring for the purpose of reducing the atmospheric deposition of toxic substances to the Great Lakes Basin Ecosystem. Since that time, substantial progress has been made in quantifying trends in atmospheric deposition, understanding relevant physicochemical processes, assessing the contributions of out-of-basin sources and identifying new compounds of concern. Join us for this hour-long interactive panel discussion as we explore what scientific information is still needed to support making the deposition of airborne toxic substances a threat of the past. *Keywords: Deposition, Toxic substances.*

GAMBLE, A.E.¹, HRABIK, T.R.¹, STOCKWELL, J.D.², and YULE, D.L.³, ¹University of Minnesota Duluth, 1035 Kirby Dr, Duluth, MN, 55812; ²Gulf of Maine Research Institute, 350 Commercial Street, Portland, ME, 4101; ³USGS Lake Superior Biological Station, 2800 Lake Shore Drive, Ashland, WI, 54891. **Trophic Connections in the Nearshore and Offshore Food Webs of Lake Superior: a Diet Analysis Approach.**

We use analysis of fish stomach contents to create a baseline food web model of both the Lake Superior nearshore and offshore fish communities. Fish were collected seasonally (spring, summer, and fall) from 18 locations in 2005 that spanned the entire lake, with five stations repeated in 2006. A total of 7,800 stomachs were examined, representing 17 species. The predominant fish species were smelt (*Osmerus mordax*), deepwater sculpin (*Myoxocephalus thompsoni*), kiyi (*Coregonus kiyi*), cisco (*Coregonus artedii*), slimy sculpin (*Cottus cognatus*), siscowet lake trout (*Salvelinus namaycush siscowet*), and bloater (*Coregonus hoyi*). The majority of fish stomachs were either empty (20% of total) or contained between one to four prey items (68%). The ability to locate prey appeared to be similar between near and offshore fish. *Mysis relicta* was the single most common prey item for all offshore fish species and for the majority of nearshore fish, suggesting that changes in *Mysis* populations could have a significant impact on the entire Lake Superior food web. *Keywords: Fish diets, Lake Superior, Food chains.*

GANNON, J.E., International Joint Commission, 100 Ouellette Ave., 8th Fl, Windsor, ON, N9A 6T3. **Revisiting the Keystone Species Approach of Integrating and Indicating Ecosystem Health in the Laurentian Great Lakes.**

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

There has been difficulty translating the ecosystem approach, as espoused in the Great Lakes Water Quality Agreement, into practical resource management applications. The development of keystone species as integrators and indicators of ecosystem health is one such method. The International Joint Commission (IJC) in cooperation with the Great Lakes Fishery Commission in 1985 developed the lake trout and the deepwater amphipod (scud) as indicators of oligotrophic ecosystems. The IJC in 1990 developed the walleye and burrowing mayfly as indicators of mesotrophic ecosystems. The keystone species approach, widely accepted as scientifically valid in aquatic and terrestrial ecology, nearly has been lost in the Great Lakes largely because: 1) monitoring programs have not been developed to specifically track the status and trends of keystone species; and 2) biological community indicators, especially the Index of Biological Integrity (IBI), have become in vogue in more recent years and have overtaken the use of keystone species as indicators of ecosystem health. Arguments are put forth here about the scientific validity and cost effectiveness of the keystone species approach as indicators of ecosystem health in the Great Lakes. Moreover, there is high potential for adapting the keystone species approach to other large lakes. *Keywords: Environmental health, Indicators, Lake management.*

GERLOFSMA, J. and BOWEN, K.L., Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Population Dynamics of Zooplankton and Rotifers in Lake Huron in 2007.**

The lower food web of Lake Huron has undergone dramatic changes following the spread of quagga mussels (*Dreissena bugensis*) and the spiny water flea (*Bythotrephes*). *Diporeia*, zooplankton, phytoplankton and alewife appear to have declined markedly since 2003. To better understand recent changes in Lake Huron, lakewide sampling of the lower food web was undertaken in spring, summer and fall of 2007 as part of a multi-agency binational effort. Nearshore zooplankton samples were taken along a depth gradient to complement the USEPA's offshore monitoring program. Total water column nets in August showed zooplankton biomass was dominated by calanoids (~75%), followed by cladocerans (~15%). The southern end of the lake was dominated by the calanoid *Diaptomus minutus* & the cladoceran *Daphnia galeata mendotae*, whereas at the mid and northern stations, *Limnocalanus macrurus* & *Holopedium gibberum* were common. Spatial and seasonal differences in density, biomass and dominant species, such as nearshore to offshore gradients, will be discussed. The 2007 zooplankton data will also be compared to earlier collections from Lake Huron. *Keywords: Lake Huron, Zooplankton, Rotifers.*

GEWURTZ, S.¹, BHAVSAR, S.P.², JACKSON, D.A.¹, FLETCHER, R.², REINER, E.J.², MOODY, R.², and AWAD, E.², ¹University of Toronto, Department of Ecology and Evolutionary Biology, Toronto, ON, M5S 3G5; ²Ontario Ministry of the Environment, 125 Resources Road To, Toronto, ON, M9P 3V6. **Trends and Current Status of Contaminants in Fish from the St. Clair River/Lake Corridor.**

Fish are useful indicators of atmospheric and point source loadings of chemicals to the Great Lakes. Here, we evaluate trends of contaminants in the St. Clair River and Lake St. Clair.

In 1970, mercury in St. Clair River fish led to a closure of the fishery. However, numerous remediation actions have since taken place, such as the closure of a chlor-alkali plant. In Lake St. Clair, mercury, polychlorinated biphenyls (PCBs), octachlorostyrene (OCS) and hexachlorobenzene (HCB) decreased consistently between the 1970s until the mid-1980s, after which the rate of contaminant decline slowed. This trend was consistent in 12 fish species comprising different trophic positions and dietary habits, suggesting that the changes were reflective of loadings rather than food web processes. Fish from the St. Clair system contained elevated concentrations of mercury, OCS, and HCB, compared with southern Lake Huron, suggesting that there are still current sources, likely from contaminated sediment. For PCBs, there were no significant differences between Lake Huron and St. Clair fish, providing evidence that the atmosphere has become its major source. A comparison of fish concentrations to consumption guidelines showed that mercury, PCBs, and dioxin-like toxicity remain of concern in lipid rich and/or predatory fish such as carp and walleye. *Keywords: Toxic substances, St. Clair River, Fish.*

GILBERT, J.M.¹, LETOURNEAU, F.², BENNETT, L.¹, JACOBS, D.³, SLAVIK, E.⁴, LOCKE, B.⁴, and DROUIN, R.⁵, ¹OMNR-LEMU, P.O. Box 429, 1 Passmore St., Port Dover, ON, N0A 1N0; ²Dover Agri-serve, RR#8, Chatham, ON, N7M 5J8; ³Friends of Rondeau, RR#1, Morpeth, ON, N0P 1X0; ⁴Rondeau Provincial Park, RR#1, Morpeth, ON, N0P 1X0; ⁵OMNR-LEMU, RR#2, 320 Milo Rd, Wheatley, ON, N0P 2P0. **Investigating Control Options for the Invasive Alien Species *Phragmites australis* subsp. *australis* (Common Reed) in Sensitive Lake Erie Coastal Habitats.**

Rapid expansion of the invasive, alien plant *Phragmites australis* within Ontario's Lake Erie coastal wetlands and the resultant decline in biodiversity, Species at Risk habitat and recreational opportunities has prompted action by resource managers. Based upon *Phragmites* management to date, the use of broad spectrum herbicides with the active ingredients glyphosate (Round-Up Ultra, Weather-max) and imazapyr (Habitat) have proven most effective for extensive plant mortality. However, unlike in the United States, Habitat is not available in Canada and aerial or over water application of chemicals for *Phragmites* control is not a legal option. Given these constraints, alternative methods were investigated for *Phragmites* management in sensitive and difficult to access areas. In 2007/08, studies were undertaken in Rondeau Bay to investigate 1) the efficacy of low residual, high LD50, grass specific herbicides in *Phragmites* control using replicate 1x1m² plots; 2) native vegetation response after glyphosate spraying of a 10 ha *Phragmites* dominated wetland; 3) *Phragmites* mortality due to cutting/rolling and natural flooding, and 4) use of non-conventional spray equipment and methods to reduce impacts on sensitive habitats. The results of these investigations will be presented *Keywords: Invasive species, Management, Wetlands.*

GILBERT, J.M.¹, DUNN, G.², SWEENEY, S.J.³, ASPINALL, J.D.³, DROUIN, R.², and LOCKE, B.⁴, ¹Ontario Ministry of Natural Resources -Lake Erie Management Unit, P.O. Box 429, 1 Passmore St., Port Dover, ON, N0A 1N0; ²Ontario Ministry of Natural Resources - Lake Erie Management Unit, 659 Exeter Rd., London, ON, N6E 1L3; ³Ontario Ministry of Agriculture, Food, and Rural Affairs, 3rd Floor SE, 1 Stone Road West, Guelph, ON, N1G 4Y2;

⁴Rondeau Provincial Park, RR# 1, Morpeth, ON, N0P 1X0. **Restoring Rondeau Bay's Ecological Integrity: Changing the Status Quo.**

Rondeau Bay is an exceptional region in southern Ontario. It provides both biodiversity and critical habitat for numerous Species at Risk. The retention of these high-value natural heritage features within the Bay's agriculturally-dominated watershed can be attributed to the presence of Rondeau Provincial Park. Within the Park's boundaries, unique Carolinian habitat and a large, hydrologically-intact, coastal wetland have been preserved. Habitats located outside of the Park, however, have not fared as well due to significant wetland losses and deforestation. Chronic, highly-degraded water and sediment quality conditions threaten the long-term sustainability of Rondeau Bay's ecosystem. A ten year restoration plan has been developed for the entire watershed. Information collected during a comprehensive ecological assessment conducted in 2005/06 has been used to set nutrient reduction and habitat restoration targets. Both new and old technologies are being applied to guide strategic management practice changes in this landscape. LiDAR-based (Light Detection and Range) digital elevation models (DEM's) and orthoimagery were used to site sediment and nutrient reduction ponds designed and built to capture and treat drainage waters from agricultural fields. Details of this project will be presented. *Keywords: Eutrophication, Restoration, Wetlands.*

GILLINGHAM, J.C. and UZARSKI, D.G., Department of Biology, Central Michigan University, Mt. Pleasant, MI, 48859. **Central Michigan University Biological Station on Beaver Island, Northern Lake Michigan.**

Central Michigan University Biological Station (CMUBS) is located on Beaver Island 32 miles northwest of Charlevoix, MI in Lake Michigan. It was established in 1966 through NSF funding. Teaching labs constructed in the 1960s were replaced in 2007 with a state-of-the-art Academic Center including three teaching labs, a computer lab, a library and a 120 seat lecture hall. CMUBS has research facilities that include space for both aquatic and molecular research. In addition to purchasing over 400 acres on the island since 1990, CMU recently acquired a former U.S. Coast Guard station in St. James Harbor at the north end of the island. The acquisition provides us with our own boat launch and deep water mooring with direct access to Lake Michigan. The mission of CMUBS is to provide students with quality courses in biology and related areas, to provide students and faculty with facilities for terrestrial and aquatic research within the Beaver Archipelago and the surrounding waters of Lake Michigan, and to provide scientific outreach to the inhabitants of Beaver Island. In 2008, an external Advisory Board was formed consisting of five established Great Lakes scientists and administrators. The board provides guidance in promoting collaboration, enhancing visibility and optimizing both academic and research utilization of facilities. *Keywords: Lake Michigan, Biological Station, Invasive species, Lake Michigan, Outreach, Funding.*

GINN, B.K., BENNETT, L., and BALDWIN, R., Lake Simcoe Region Conservation Authority, 120 Bayview Parkway, Newmarket, ON, L3Y 4X1. **Relationship of Aquatic Plant Distribution to Phosphorus, Substrate Type, and other Limnological Variables in Lake Simcoe (Ontario, Canada).**

Lake Simcoe, the largest inland lake in southern Ontario, has been the focus of much public and scientific attention primarily due to high nutrient loadings and a lack of coldwater fish habitat. While many studies have focused on trends in water chemistry and fish stocks in this lake, the nearshore zone (0-20 m depth) has been virtually ignored. This zone is an important terrestrial-aquatic linkage, serves as critical nursery habitat to fish, and is the part of the lake used by humans for recreation. In recent years, the nearshore zone of Lake Simcoe has experienced dramatic environmental changes due to shoreline alteration, changes in surface runoff, and phosphorus shunting by dreissenid mussels. In order to fully investigate these changes, and gauge the full extent of their impact, we are undertaking a multi-disciplinary limnological study which uses biomonitors to track environmental change in Lake Simcoe and find out (a) where changes are taking place; (b) what is the cause of these changes; and (c) are mitigation targets adequate to restore water quality. In this study, we collected surveyed aquatic plant communities along 43 transects in Lake Simcoe to determine species composition, biomass, and distribution with respect to key environmental variables such as depth, substrate type, and phosphorus concentration. *Keywords: Lake Simcoe, Aquatic plants, Biomonitoring, Invasive species.*

GINN, B.K.¹, BENNETT, L.¹, MORTON, W.B.², BALDWIN, R.¹, and KILGOUR, B.³, ¹Lake Simcoe Region Conservation Authority, 120 Bayview Parkway, Newmarket, ON, L3Y 4X1; ²3 Woodrbridge Dr, Guelph, ON, N1H 7E3; ³Kilgour and Associates Ltd., 1500 Bank St., Suite 427, Ottawa, ON, K1H 1B8. **Assessment of Environmental Changes in Lake Simcoe (Ontario, Canada) Using Benthic Invertebrates as Proxy Indicators: Relationship of Community Structure and Limnological Conditions.**

Lake Simcoe has been the focus of many environmental studies due to concerns of high nutrient loadings and a decline in the availability of coldwater fish (e.g. trout and whitefish) habitat. One method of rapidly assessing fish habitat, and other environmental conditions, is the use of benthic invertebrates. Composed predominantly of insect larval stages, certain species can be sensitive or tolerant of environmental conditions (e.g. deepwater oxygen levels). Thus, while it is often not possible to continually monitor a suite of limnological variables, benthos samples collected at fall turnover can provide critical environmental. In this study, we collected benthos samples from 33 stations in Lake Simcoe representing three general habitats: shoreline (0-1 m depth), littoral (7 m depth) and profundal (20 m depth). After establishing a relationship between community structure and limnological variables, the current (2008) community was compared with previous years to assess how the benthic community, and environmental conditions, in Lake Simcoe have changed with respect to nutrient loading, availability of coldwater fish habitat, dreissenid invasions, and success of environmental mitigation strategies. *Keywords: Lake Simcoe, Zebra mussels, Benthos, Biomonitoring.*

GLASSNER-SHWAYDER, K.M., JENSEN, E.S., and EDER, T.A., Great Lakes Commission, 2805 South Industrial, Ann Arbor, MI, 48104. **Advancing Aquatic Invasive Species Management of Organisms in Trade in the Great Lakes Region.**

Aquatic invasive species (AIS) are a well-documented threat to the integrity of the Great Lakes basin ecosystem. To minimize AIS introduction and spread, a vector-based approach to management is being utilized by state and federal governmental agencies to interrupt the pathways by which AIS move from one location to another. With the expansion and globalization of trade, there is mounting concern in the Great Lakes region over invasion risks posed by the organisms in trade (OIT) vector and associated pathways (such as aquarium and pet trade, nursery and water garden outlets, aquaculture, and bait, among others). The Great Lakes Commission is investigating the OIT vector in a regional initiative to address fundamental challenges regarding high-risk pathways and associated species, business practices and consumer behavior, and management approaches (e.g., regulatory, voluntary and education/outreach). The overall goal is to identify new management, information technology and policy tools and extend existing efforts to help reduce the risks of aquatic invasions through the OIT vector. Integral to the Commission's work is engaging key stakeholders from the scientific community, governmental agencies, industry and trade groups, and NGOs to work collaboratively on building and implementing viable solutions to the OIT challenge. *Keywords: Organisms in trade, Aquatic invasive species.*

GOGINENI, P., JANUSKA, B., MINNIEFIELD, C., and SIMOLIUNAS, S., Detroit River Remedial Action Council, 665 W. Warren Ave, Detroit, MI, 48201, USA. **The Necessity of Carbon Filtration for Water and Wastewater Treatment.**

Water being universal solvent carries many organic compounds as well the toxic disinfection products, which can be removed only by carbon filtration. It is important to note that many water and wastewater treatment plants do not have carbon filtration. The permits should specify carbon filtration. *Keywords: Carbon filtration, Water, Wastewater.*

GOMEZDELCAMPO, E. and SANDERSON, L.M., 190 Overman Hall, Bowling Green, OH, 43403. **Changes in Fish Diversity Due to Hydrologic Variability in the Sandusky River, Ohio: a Genetic Algorithm Application.**

The Sandusky River Basin is a vital fish nursery for numerous fish species, which depends on maintaining a high level of fish diversity. The overall objective of this study is to answer two main questions: how are varying flow and suspended sediment affecting the fish of the Sandusky River, and are different biological indices impacted by similar variations in flow and suspended sediment. In order to quantify fish diversity we define fish habitat in terms of flow and suspended sediment. Data from the USGS gage in the Sandusky River as well as 16 years of fish data collected by the Ohio Environmental Protection Agency and the Ohio Division of Wildlife were used in this study. The Indicators of Hydrologic Alteration program was used to generate different hydrologic and suspended sediment variables that were run through a genetic algorithm to determine the Shannon Index, the Simpson Index, and Species Richness. The genetic algorithm produced a single equation with all the variables deemed important to a specific biodiversity index. Flow and suspended sediment were shown to be important at multiple levels in the Sandusky River, with common variables found among the three indices.

There are many complex factors of flow and suspended sediment affecting fish diversity in the Sandusky River. *Keywords: Ecosystems, Computer models, Fish.*

GOREY, C.¹, ESCOBAR, I.¹, ZAKY, A.², CAI, G.², and GRUDEN, C.L.², ¹Department of Chemical and Environmental Engineering, The University of Toledo, Toledo, OH, 43606; ²Department of Civil Engineering, The University of Toledo, Toledo, OH, 43606. **Cellulose Acetate Ultrafiltration Membranes Modified with Temperature-Sensitive Polymers for Fouling Resistance.**

Most drinking water treatment facilities have water intakes from large bodies of water. In the Midwest, much of the intake for potable water comes from the Great Lakes. This water needs to go through various methods of cleaning such as sand filtration and activated carbon filters. Membranes are becoming more popular as the cost of installation decreases and filtration performance increases. One restriction for the use of membranes is the accumulation of contaminants on the surface called fouling. Fouling can manifest as biofouling, meaning bacteria accumulate on the surface along with their waste products; organic fouling, such as humic and fulvic acids; and inorganic fouling, such as metal ions and salts. Layers placed on a membrane surface with specific properties can inhibit adsorption and bacterial growth. This work was to produce a fouling-resistant membrane by attaching a stimuli-responsive polymer on the membrane surface, which collapsed or expanded as a response to the stimulus. The phase change arises from the existence of a lower critical solution temperature (LCST) such that the polymer precipitates from solution as the temperature is increased. The polymers studied for this application were hydroxypropyl cellulose and N-isopropylacrylamide, which have LCSTs of 46°C and 32°C, respectively. *Keywords: Environmental contaminants, Drinking water, Polymers.*

GOREY, C.¹, KOLINSKI, C.², SEGER, T.², and ECKMAN, D.², ¹Department of Chemical and Environmental Engineering, The University of Toledo, Oregon, OH, 43606; ²Clay High School, 5665 Seaman Road, Oregon, OH, 43616. **Analysis of Agricultural Run-off in Wolf Creek.**

Wolf Creek is a waterway close to Clay High School, Oregon, OH, that runs directly into Maumee Bay and has been attributed to be one of the sources of bacterial contamination to Maumee Bay. Also, much agricultural run-off occurs since the creek flows through a rural farming community. The work presented here was intended to measure several water quality parameters of Wolf Creek over the course of one year. Coliform counts along with phosphate and turbidity measurements were taken as the selected key parameters. Data taken in late winter and early spring were compared to summer and fall data that was already available. Winter and spring sampling procedures were identical to summer and fall methods according to the protocol issued from Student Watershed Watch. The hypothesis of this work was that measurements would be dependent on the weather. For example, precipitation affects run-off, while warming affects bacterial growth. Also, as the ground warms, farmers start tilling and applying fertilizer to prepare for the growing season. Depending on fertilizer loading and rainfall, the stream displays varying levels of coliform, phosphates, and turbidity. *Keywords: Monitoring, Education, Agricultural run-off.*

GORMAN, O.T., USGS Lake Superior Biological Station, 2800 Lake Shore Drive East, Ashland, WI, 54806. **The Demersal Fish Community of Offshore Waters of Lake Superior: Stability in the Midst of Change in Nearshore Communities?**

The demersal fish community of the offshore zone (> 80 m depth and >5 km offshore) was described from bottom trawl surveys conducted between 2001 and 2008. Based on the results of 111 bottom trawl samples taken 5-60 km offshore at depths of 40-327 m, the dominant species of the offshore community were siscowet lake trout, kiyi, and the deepwater sculpin. Other species commonly encountered in offshore waters included lake whitefish, pygmy whitefish, bloater, cisco, shortjaw cisco, slimy sculpin, spoonhead sculpin, and burbot. Composition of this deepwater community was relatively homogenous across broad regions of Lake Superior, but with increasing depth the species composition changed and the number of species declined. At depths >160 m the community was largely limited to siscowet, kiyi, deepwater sculpin, and burbot. Comparison of 2001-2004 to 2005-2008 samples indicated a change in composition in the 80-160 m depth zone that was highlighted by a shift in depth distribution of lean lake trout from nearshore (< 80 m depth) to offshore waters. Coinciding with this change was a decline in biomass of important nearshore zone prey fishes; cisco, bloater, and rainbow smelt. Continuing recovery of lake trout populations is hypothesized to be driving the observed changes in community composition in near and offshore waters. *Keywords: Fish populations, Habitats, Lake Superior.*

GOSMAN, S.R., 1401 Pear St., Ann Arbor, MI, 48105. **Compact Implementation: Progress Report and Next Steps.**

The Great Lakes-St. Lawrence River Basin Water Resources Compact requires each of the eight Great Lakes states to implement the Compact by taking certain actions over the next five years. Many of these actions involve significant administrative, regulatory, and legislative decisions. Some states have enacted comprehensive implementing legislation, others have delegated decision-making responsibility to state agencies, and yet others are relying on existing programs. The presentation will examine the progress by the states and highlight the gaps in implementation. The presentation will also consider how the Compact Council and stakeholders can use the cooperative Compact structure to further protect the Great Lakes. *Keywords: Regional analysis, Environmental policy, Legislation.*

GOTTGENS, J.F., ARCEO, A.I., and CRAIL, T.D., Dept. of Environmental Sciences, MS 604, The University of Toledo, Toledo, OH, 43606. **Effects of a Low-Head Dam Removal on the Fish Community in a Great Lakes Tributary.**

Dams block fish migration and may impact fisheries. Few studies, however, have quantified fish movement in dammed rivers pre- and post-removal. We contrasted fish communities up- and downstream from the last remaining dam in the Ottawa River (Ohio) by repeated block-seine sampling before (2003-04) and after (08) dam removal. More than 2,000

fish (30 species) were identified, measured, assessed for condition and released. Up- and downstream QHEIs were comparable, as were DO, conductivity, pH, temperature, canopy cover and discharge at each sampling event. Following dam removal, fish abundance, richness and diversity doubled upstream with migrating catostomids (*Catostomus commersoni*), sunfish (*Lepomis* spp.), percids (*Perca flavescens*, *Percina caprodes*), cyprinids (*Cyprinella spiloptera*, *Notropis atherinoides*) and *Dorosoma cepedianum* gaining access to upstream habitat. Abundant larval fish upstream of the old dam site pointed to improved spawning success. Upstream trophic structure switched from an omnivorous to an invertivore-dominated fish assemblage. Exotic round goby, absent in 2003-04, made up 22% of the downstream and 5% of the upstream catch in 08. Sampling will continue in 09. Despite its small size, the dam impacted the fish community in the Ottawa and, by extension, western Lake Erie. *Keywords: Fish, Tributaries, Lake Erie.*

GRABARKIEWICZ, J.D. and CRAIL, T.D., University of Toledo, 2801 W. Bancroft St., Toledo, OH, 43606. **Three Years of Unionid Surveys in Swan Creek, Lower Maumee River Watershed, Lucas County, Ohio.**

Swan Creek drains 530 km² of agricultural, oak savanna, and (sub)urban land into the lower Maumee River of western Lake Erie in Toledo, Ohio. Sporadic mollusk collections were made in the early and mid 1900s on Swan Creek, but systematic surveys were not performed. Using qualitative, semi-quantitative, and quantitative sampling techniques, a total of 109.9 person-hours were spent surveying 21 stations on Swan Creek between April 2006 and September 2008. Surveys covered 43.8 river kilometers (RK 50.7 to 6.9) and documented 1,734 live unionids. A total of 17 species were found live with an additional seven species represented by shell only. Recruitment was documented for 11 species. Abundance and diversity were highest in the middle portion of the river (RK 28.3-24.6). A major find was the discovery of a new population of reproducing rayed bean (*Villosa fabalis*), an Ohio state endangered and federal candidate species. *V. fabalis* was the fifth most abundant species sampled with 244 found live representing 14.1% of the total sample. The Ohio state endangered snuffbox (*Epioblasma triquetra*) was also found, although as shell only. Swan Creek, although impacted by anthropogenic disturbance, still supports a remarkable freshwater mussel community. *Keywords: Unionids, Mollusks, Monitoring.*

GRABAS, G.P., Environment Canada, 4905 Dufferin Street, Toronto, ON, M3H 5T4. **Monitoring Coastal Wetlands in a Great Lakes Area of Concern: Application of a Regional Framework.**

Over 20 years ago, the IJC Water Quality Board identified Great Lakes locations with degraded environmental quality. There were 25 Great Lakes Areas of Concern (AOCs) in the United States, 12 sites in Canada and five in bi-national connecting channels. In most cases, Canadian AOCs exhibit impairments to fish and wildlife populations and their habitats (i.e., BUIs 3 and 14). Although much work has been done to address other BUIs, there is often a lack of specific data for fish and wildlife populations and their habitats in coastal wetlands. This presentation details the application of a regional coastal wetland monitoring framework to quantitatively evaluate fish and wildlife habitats and populations in the Bay of Quinte AOC.

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

Since 2005, water quality, submerged aquatic vegetation, nektonic macroinvertebrates, fish, and breeding marsh birds have been evaluated using indices. The results have contributed to delisting criteria for BUI 3 and 14. For fish and wildlife populations, delisting criteria include showing that these populations are among the best in Lake Ontario. For habitat loss, indices are used to evaluate water quality, submerged aquatic vegetation, and nektonic macroinvertebrates. Bay of Quinte coastal wetlands were generally in better condition than other Canadian sites along the shoreline of Lake Ontario. *Keywords: Area of Concern, Bay of Quinte, Coastal wetlands.*

GRABUSKI, J.M., CAGAMPAN, S.J., STRUGER, J., and SMITH, E.C.P., Environment Canada, Burlington, ON, L7R 4A6. **Automated Solid Phase Extraction of Carbamate Pesticides in Fortified Water and Natural Water Samples using LC-ESI/MS/MS.**

The identification and determination of carbamate pesticides have presented a challenge, both in specificity and sensitivity, when using conventional analytical techniques. Recent advances in solid phase extraction (SPE) technology combined with liquid chromatography tandem mass spectrometry (LC/MS/MS) have greatly improved this process. Hence, we developed a sensitive and robust analytical technique with supporting method detection limits (MDLs) using fortified Type 1 water. The applicability of the analytical method was then investigated in 2008 on approximately 100 natural water samples from urban and rural watersheds including the Niagara River in Ontario. Six carbamate insecticides and one fungicide in water were simultaneously extracted by an automated Autotrace SPE Workstation. The 800ml fortified or natural water samples were loaded onto an Oasis HLB cartridge at a flow rate of 5ml/min, dried with nitrogen for 10 minutes, eluted with 8ml of methanol and concentrated to 1ml for analysis by LC-ESI/MS/MS. Recoveries in the spiked Type 1 water samples were 96% or higher for all compounds. Instrument and method detection limits ranged from 0.33 to 9.88 pg/ul and 0.7 to 22.0 ng/l, respectively. Maximum observed concentrations in natural water samples were 949 ng/L for carbaryl, 899 ng/l for methomyl and 292 ng/L for oxamyl. *Keywords: Pesticides, Tributaries, Water quality.*

GRANADOS, M.¹, MANDRAK, N.E.², and JACKSON, D.A.¹, ¹Department of Ecology and Evolutionary Biology, 25 Willcocks Street, Toronto, ON, M5S 3B2; ²Department of Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Measuring Changes in the Fish Assemblages of the Huron-Erie Corridor Areas of Concern.**

The 1972 US-Canada Great Lakes Water Quality Agreement designated the degraded Detroit and St. Clair Rivers as Areas of Concern. The agreement requires the development of a Remedial Action Plan (RAP) to determine the causes and severity of environmental degradation, selection of remedial actions, implementation and assessment. Projects have been implemented to increase habitat, remove contaminated sediments and eliminate combined sewer outflows. The RAP is assessed through a variety of indicators, including the Index of Biotic Integrity (IBI), a multimetric index for biological assessment. The IBI was applied to fish assemblage data from the Detroit and St. Clair Rivers. The results did not indicate a significant increase in IBI scores following the implementation of the projects. Multivariate analyses were applied to the fish assemblage data to measure changes in the assemblage using a non-multimetric approach.

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

Principal Coordinates Analysis ordinations were generated and coded for sampling year. The ANOSIM result does not indicate significant changes in the Detroit River data across sampling years, however the St. Clair River data indicate a change in the fish community that is not detected in the IBI scores. Thus multivariate analyses and the IBI can generate different interpretations of the community data. *Keywords: Detroit River, Bioindicators, Remediation.*

GRAPENTINE, L.C., Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6.
Adjusting Bioassessments of Sediments for Changing Benthic Communities in Reference Sites in the Great Lakes.

Since the early 1990s, benthic macroinvertebrate communities have been periodically sampled from sediments in over 200 undisturbed sites in nearshore areas of the Great Lakes. The data obtained are used to describe reference conditions for impact assessments of benthic communities in contaminated sediment sites. Through the years, reference sites in the Great Lakes have been affected by invasive species, climate change, and other regional stressors, potentially resulting in unstable or moving benchmarks for bioassessments of test sites. The simplest approach for accommodating variable reference conditions in environmental assessments is to exclude older data determined to be nonrepresentative of current conditions. Alternatively, reference condition descriptions may be able to be statistically adjusted using bioassessment models that include time or nuisance stressor variables as predictors, allowing use of older data and quantification of time trends. Examples of these procedures will be shown for Environment Canada's program of benthic assessments for Areas of Concern in the Great Lakes. *Keywords: Benthos, Assessments, Sediments.*

GRATZ, L.E., KEELER, G.J., and DVONCH, J.T., University of Michigan Air Quality Lab, 109 S. Observatory SPH1, Ann Arbor, MI, 48109, USA. **Atmospheric Mercury Transport across Southern Lake Michigan: Influence from the Chicago/Gary Urban Area.**

Defining the local and regional impacts of atmospheric mercury (Hg) emissions from major urban and industrial sources in the Chicago/Gary urban area is critical to improving our understanding of atmospheric Hg transport and deposition in the Great Lakes region. Speciated atmospheric Hg was measured in Chicago, IL and Holland, MI from July to November 2007 to better characterize the impact of Chicago/Gary on southwest Michigan. These continuous measurements of elemental Hg (Hg⁰), divalent reactive gaseous Hg (RGM), and fine particle bound Hg (Hg^P) are useful for understanding atmospheric Hg chemistry and differentiating between local and regional source impacts due to the different behaviors of reactive and elemental Hg. Results from 2007 show that, on average, Hg⁰ and Hg^P were 1.5 times higher and RGM was 2 times higher in Chicago than in Holland. Meteorological analysis indicates that transport across the lake from Chicago/Gary occurred frequently during the study, and ambient concentrations in Holland were greatly elevated during transport episodes. A summary of results from the 2007 study and case studies of transport episodes will be presented in order to further explain the impact of Chicago/Gary on southwest Michigan and distinguish local impacts from regional transport. *Keywords: Mercury, Lake Michigan, Atmospheric transport.*

GROOCOCK, G.H., FRATTINI, S.E., ECKERLIN, G.E., GETCHELL, R.G., WOOSTER, G.E., HEATH, W.T., HOPE, K.M., CASEY, R.N., FARRELL, J.M., CASEY, J.W., and BOWSER, P.R., Aquatic Animal Health Program, Veterinary Medical Center, Cornell University, Ithaca, NY, 14853. **The Emergence of Viral Hemorrhagic Septicemia Type IVB in the Great Lakes.**

This presentation will briefly describe the history of Viral Hemorrhagic Septicemia virus (VHSV) as a major fish pathogen through its most recent emergence in the Great Lakes and the subsequent spread of the outbreak in the past few years. The initial isolation of VHSV occurred in Lake St. Clair in muskellunge and in the Bay of Quinte in freshwater drum in 2005. Since then the virus has been isolated from muskellunge tissues that were collected and stored in 2003. The first detection of VHSV in New York State waters occurred in May 2006 in a mortality event of round gobies collected from the St. Lawrence River. Isolations of VHSV in 2006 included 21 different events from 16 locations, including the first inland isolation in Conesus Lake. A surveillance effort of healthy fish from the St. Lawrence River detected VHSV in an additional 12 species. More isolations of VHSV were identified in 2007 and 2008 in the Great Lakes and a number of inland water bodies. Data from a 2008 surveillance of healthy fish and water samples collected from 30 locations along the coastline from the St. Lawrence River to Lake Huron will be presented. The impact of VHSV and the potential future implications of this emerging pathogen will be discussed. *Keywords: Fish populations, Genetics, Fish diseases.*

GUILDFORD, S.J.¹, HECKY, R.E.¹, GONDWE, M.², MACUIANE, M.A.³, and NGOCHERA, M.⁴, ¹Dept. of Biology and Large Lakes Observatory, University of Minnesota Duluth 2205 E. 5th St., Duluth, MN, 55812; ²University of Waterloo, Waterloo, ON; ³World Fish Centre, Domasi, Malawi; ⁴Malawi Department of Fisheries and Agriculture, Senga Bay, Malawi. **Initial Primary Productivity Estimates in Lake Malombe, Malawi following Invasion by an Exotic Asian snail.**

Lake Malombe is a large (450 km²), shallow (Z_{max} 4.8 m), riverine lake receiving the outflow of Lake Malawi via the Shire River. Fish yields (FY) declined in the 1990's from 130 kg/ha/y to 40 kg/ha/y. Although overfishing has been invoked to explain the decline, other factors may be involved. Increased sediment loads in southern Malawi rivers may have impacted primary productivity (PP), and in the 90s the lake was invaded by an exotic snail, *Melanoides tuberculata*, whose biomass has increased dramatically perhaps disrupting energy flow. In Jan 2009 an initial survey was conducted to estimate PP by diurnal oxygen change and PAM fluorometry. PP ranged from 150 mg/m²/h in the river plume to approximately 1,000 mg/m²/h over most of the lake. Chlorophyll concentrations were 3-5 mg/m³ in the river plume to 30-50 mg/m³ in the lake. Cyanobacteria dominated the lake phytoplankton, and the potentially toxic *Cylindrospermopsis raciborskii* was dominant. PP is likely light limited by high algal biomass and resuspended sediments. Based on PP-FY regression for African lakes, current yields from Malombe are well below expectation and the lake is trophically inefficient in terms of fish production. *Keywords: Exotic species, Productivity, Africa.*

GUO, J.¹, WATSON, S.B.¹, YERUBANDI, R.¹, and PAGE, S.², ¹Environment Canada, Water Science & Technology, 867 Lakeshore Road, Burlington, ON, L7R 4A6; ²Fisheries & Oceans Canada, Freshwater Institute, 501 University Crescent, Winnipeg, MB, R3T 2N6. **Sediment Nutrients and Bioavailability in Lake Winnipeg.**

Lake Winnipeg has been experiencing increasing frequent and duration of algal blooms, as a result of nutrient pollution from human activities throughout its watershed. Considerable amount of the nutrients is thought to be associated with particulate-bound material, transported and deposited with the sediment and subsequently released back into the water column as part of the nutrient flux. The relative and absolute importance of these processes in the overall nutrient budget is largely unknown. A few selected sediment samples taken from the south basin were analyzed by earlier work, but there is little information about other areas in the lake, notably the north basin where the majority of blooms occur. To address this knowledge gap and improve earlier analytical methods to allow for larger sample throughput, we sampled the lake during 2008, and collected fifty sediment samples at selected monitoring sites. These were analyzed for particle size distribution, organic and inorganic carbons, metals and nutrients. The measurement of bioavailable phosphorous, which has been directly linked to primary production, was carried out with an improved technique, based on an earlier procedure developed and applied to the selected samples from this ecosystem (Mayer et al., 1991). The preliminary data showed key dif
Keywords: Sediments, Phosphorus, Nutrients.

GUZZO, M.M., FISK, A.T., and HAFFNER, G.D., 401 Sunset Ave., Windsor, ON, N9B 3P4, Canada. **Seasonal and Spatial Variation in Stable Isotope and Fatty Acid Values in Seston from the Western Basin of Lake Erie.**

Chemical tracers were used to assess seasonal and spatial variation in seston signatures. This type of technology has become increasingly popular in studying food webs. The Western Basin of Lake Erie is one of the most complex ecosystems in the Great Lakes Basin. It is fed by two major rivers; the Maumee and Detroit. These two water sources vary greatly in their nutrient composition, temperature and flow rates. The Maumee River is highlighted by warm, slow currents, rich in nutrients, while Detroit River is dominated by cool, fast moving water and poor nutrient levels. These major differences between water/nutrient inputs are predicted to create both seasonal and spatial differences in seston. To examine this seasonal and spatial variation in seston, the Western Basin of Lake Erie was sampled from June-September of 2008 and analysed for stable isotopes (SI) of carbon and nitrogen and fatty acids (FA). Preliminary data has shown variation in SI and FA signatures, both seasonally and spatially. This method of analysis can be further used to compare larval fish survival to their foraging grounds. *Keywords: Stable isotopes, Fatty acids, Lake Erie, Western Basin, Zooplankton, Seston.*

HAAS, R.C.¹ and TOWNS, G.², ¹Michigan DNR, 33135 S. River Rd., Harrison Township, MI, 48045; ²Michigan DNR, 26000 W. Eight Mile Road, Southfield, MI, 48034. **Walleye Movements and Fisheries in the Huron-Erie Corridor.**

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

Walleye are one of the most sought after sport fish species in the Lake Huron to Lake Erie connecting waters. Recently, the Lake Erie Committee expressed much concern over dwindling walleye stocks in Lake Erie and the Thames River, a major tributary to Lake St. Clair. Walleye tagging in 1978–1998 at Lake Erie spawning sites near Monroe and the Huron River showed a tendency for upstream movement of walleye into the Detroit River, Lake St. Clair, and the St. Clair River. They found that about 25% of the tagged fish were caught in the Detroit River or further north. Interagency data from 1999–2003 showed upstream movement with 20% of all tags again recovered north of Lake Erie although these tags were applied at locations further east. While, these studies clearly demonstrated that adult Lake Erie walleye contributed substantially to those connecting channel fisheries, estimates of numbers of adult walleye that had migrated north out of Lake Erie were not available because the extent of the sport fishery in the connecting channels was unknown. Intensive creel surveys in Michigan waters of the Huron-Erie corridor during 2002-2005 provided information on the walleye fishery making it possible to estimate the number and movement pattern of adult walleye moving north out of Lake Erie through the connecting channels. *Keywords: Fish management, Fish tagging, Walleye.*

HALLESY, T.E.² and GOETTEL, R.G.², ¹University of Illinois, IL-IN Sea Grant Program, 336 NSRC, MC-635, 1101 W. Peabody, Urbana, IL, 61801; ²University of Illinois, IL-IN Sea Grant Program, 390 NSRC, MC-635, 1101 W. Peabody, Urbana, IL, 61801. **Lake Michigan Exploration Workshop--Synthesizing Research for Classroom Application.**

COSEE Great Lakes, in partnership with the Great Lakes Sea Grant Network, conducted the Lake Michigan Exploration Workshop in Aug. 2008 to immerse 4th-10th grade teachers in the science of this important Great Lake. Participants gained practical experience in the field, worked with researchers, examined curricula, and explored classroom activities relating to the Great Lakes and ocean resources. Topics included use of the Lake Michigan waterfront; ecosystems and habitats; contaminants in GL organisms; beach morphology/consequences of erosion and deposition; and alteration of benthic communities. This workshop fostered two-way dialogue between scientists and educators who teach biology, environmental science, and math. Through this interaction, participants developed skills in water quality monitoring, data acquisition & analysis, and concept mapping. This workshop has built lasting relationships and made a strong impression on both scientists and teachers. Workshop evaluation indicated the value of this professional development —one researcher noted, “As scientists, we usually revolve around our own little research projects and forget how important it is to get what we know out to the general public, and even more importantly, to educators.” This presentation will also share the many benefits expressed by teachers. *Keywords: Education, Ecosystems, Lake Michigan.*

HALLESY, T.E., University of Illinois, Illinois-Indiana Sea Grant, 1101 W Peabody Dr., 336 NSRC, MC-635, Urbana, IL, 61801. **Community Stewardship through Environmental Education—A Model Project.**

This session will address a new University of Illinois Natural Resources and Environmental Sciences service-learning course that engages students in relevant and meaningful

service and extended learning outside the classroom and into local community schools. In addition to enhancing academic understanding about issues related to Great Lakes aquatic invasive species, students engage in discussions with researchers and learn how to value diversity in underserved populations; how to affect change; and how to develop leadership and communication capacities to inspire environmental action in others to prevent spread of aquatic invaders. The course was sponsored by the Provost's Initiative for Teaching Advancement, University of Illinois Extension, Illinois-Indiana Sea Grant, and COSEE Great Lakes. "Service-learning is recognized for its benefits to student learning and development." (Astin & Sax, 1998). Students' final portfolios indicated the deep understandings they gained from their service-learning experience and how the skills and knowledge from the course would benefit them in their future endeavors. The presenter will provide concrete examples of what made this course so valuable to the university students and instructors, as well as the benefits to partnering school teachers and students and community organizations. *Keywords: Invasive species, Ecosystems, Education.*

HAMBUSCH, G.¹, FINNOFF, D.², and SHAFFER, S.², ¹School of Finance and Economics, University of Technology Sydney, P.O. Box 123 Broadway, Sydney, NSW 2007, Australia; ²Department of Economics and Finance, University of Wyoming, Laramie, WY, 82070.

Optimal Stochastic Environmental Policies Implications for Aquatic Invasive Species.

Several invasive species have caused substantial environmental impacts in the Great Lakes region by altering food chains and native biodiversities of ecosystems. To address these situations, the strategies facing policy makers can be considered as investments in environmental policy. One such policy considers the optimal management of an invasive species that causes damages over time using a one-time policy control investment that fundamentally alters the time path of the invasive species (through partitioning of the habitat of partially invaded ecosystems or through interrupting long distance dispersal). This paper develops a policy menu to optimally control an aquatic invasive species, such as zebra mussels (*Dreissena polymorpha*). This stochastic control problem answers the following questions: (1) Given a situation with current damages, should a control investment be executed or not? (2) Which control strategies can be suggested to combat damages based on a mean reverting invader growth subject to stochastic jumps? (3) Given the scale of the damaged ecosystem, which control strategy should be chosen? (4) What are the critical damage levels at which investment is optimal? Answers to these questions depend on the species population characteristics that determine the stochastic damage process and the control strategy. *Keywords: Biological invasions, Risks.*

HANSEN, E.C.¹, FISHER, T.G.², and BJÖRCK, S.³, ¹Geological and Environmental Sciences, Hope College, Holland, MI, 49423; ²Dept. of Environmental Sciences, University of Toledo, Toledo, OH, 43606-3390; ³Department of Geology, Quaternary Sciences, Lund University, Lund, SE-223 62, Sweden. **Quasi-periodic Cycles in Sand Abundances in Peat from a Raised Bog in Allegan County, Michigan: an Indication of Cycles in Great Lakes Storminess?**

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

As part of an ongoing effort to reconstruct the paleoclimatic history of the Lake Michigan coastal zone, we present preliminary results from a cored sequence near the center of a small (300 m diameter) bog 18 km from Lake Michigan. The bog is on a sandy plain with stabilized dunes. The core records a terrestrialization sequence with basal sand overlain by 15 cm of clay, 1.9 m of gyttja, and 3.6 m of peat. Presently 2 radiocarbon ages constrain an age model but additional dates are forthcoming. Peat deposition began at 8000 cal yr. BP. Within the peat an upcore stepwise decrease in OBD (organic bulk density) suggests increasing aridity. Superimposed shorter cycles of ~ 500 year duration indicate quasi-periodic changes in surface wetness. Sand densities in peat range from nearly 1,000 to less than 1 grain/cm³ and display quasi-periodic cycles that may reflect changes in storminess controlling the amount of sand blown into the bog. The cycles in sand density are shorter than the cycles in OBD with an average period of ~150 years. Both cycles are similar to late Holocene cycles of dune mobility and lake level fluctuations along the western Michigan coast. Variations in storminess may be the root cause of lake level variability in the Lake Michigan basin and cyclical activity of coastal dunes. *Keywords: Sediments, Holocene, Lake Michigan.*

HANSEN, T., CONSI, T.R., BOOTSMA, H.A., and KLUMP, J.V., University of Wisconsin-Milwaukee Great Lakes WATER Institute, 600 E. Greenfield Ave., Milwaukee, WI, 53204. **The Great Lakes Urban Coastal Observing System – Design and Performance.**

The Great Lakes Urban Coastal Observing System – Design and Performance. For the past three years we have designed, built and deployed a multipoint coastal monitoring system for Milwaukee Harbor and nearby coastal Lake Michigan. Called GLUCOS for Great Lakes Urban Coastal Observing System, it consists of an array of sensor laden buoys that can gather data simultaneously from several locations and transmit the data back to scientists at the WATER Institute in near real-time. The evolution of the system's design over three field seasons of operation will be presented along with data returned by the buoys. Two new extensions of the GLUCOS system will also be presented. First, the results of our initial attempts at using GLUCOS for adaptive sampling of *E. coli* in storm runoff. The buoy modifications, water sampler integration, software, and the initial tests of the system will be discussed. Second, will be a presentation of the first deployment of the bottom station, an instrumented tripod designed for benthic and water column sensing. Two sensors were mounted on the bottom station for its first tests, an upward looking acoustic fish finder and an underwater video camera. Future directions for GLUCOS science and engineering will conclude the presentation. *Keywords: Observing systems, Buoys, Computer models.*

HANSON, A.M., BERGES, J.A., and YOUNG, E.B., Dept Biological Sciences, University of Wisconsin Milwaukee, Milwaukee, WI, 53211. **Viruses in Lake Michigan and a Eutrophic Pond: A Seasonal Study of the Biological Factors Controlling Viral Abundance across Three Freshwater Locations.**

Viruses are ubiquitous in aquatic ecosystems and influence nutrient cycling through lysis of phytoplankton and bacteria, but the biological factors controlling aquatic viruses are poorly understood. Viral abundance (VA) can differ between and within lakes over space and time. VA

is commonly correlated with bacterial abundance (BA) and chlorophyll (chl). We aimed to examine seasonal variability of VA, BA and chl between freshwater ecosystems of differing trophic status by comparing oligotrophic Lake Michigan and a eutrophic urban pond. Surface water samples were collected from nearshore Lake Michigan (<100 m from shore, <10 m deep) offshore Lake Michigan (>2 km from shore, >10 m deep) and the pond (4047 m², 1.8 m deep). VA and BA were determined by epifluorescence microscopy and chl spectrophotometrically. Chl, VA, and BA were all higher in the eutrophic pond than Lake Michigan. In the pond, there was no seasonal trend in VA and BA but chl varied, increasing in spring and declining in fall. In contrast, chl was consistently low in Lake Michigan, while VA and BA varied seasonally. In both ecosystems, VA is more closely correlated with BA than with chl. To clarify the significance of this viral abundance, current laboratory experiments are examining bioavailability of P released by viral cell lysis. *Keywords: Bacteria, Virus, Microbiological studies.*

HAPONSKI, A.E., SEPULVEDA VILLET, O.J., and STEPIEN, C.A., 6200 Bayshore Rd., Toledo, OH, 43618. **Spatial and Temporal Genetic Patterns of Lake Erie Yellow Perch.**

Yellow perch is one of the most important commercially exploited fish species in the lower Great Lakes with current stocks facing considerable pressure from habitat alteration and loss, pollution, nonindigenous species invasions, and likely, climate change. We genetically tested 640 spawning fish from 13 primary Lake Erie spawning sites using 14 nuclear microsatellite loci. Bayesian structure, Monmonier geographic networks, and pairwise comparisons are used to test temporal changes in genetic composition and spatial divergence patterns among the sites. Temporal comparisons include 6 southern shore sites; Dunkirk (2001,08), Presque Isle (2001,08), Perry (2003,08), Cleveland (2002,08), and Cedar Point (2002,08). Preliminary Bayesian STRUCTURE results based on all years (2001, 2002, 2003, and 2008) and sites ($N=13$) delineate 3 primary spawning groups of yellow perch in Lake Erie: eastern basin, southern shore of western-central basins, and northern shore. Genetic BARRIER analysis reveals that the most significant barrier separates the eastern basin from the remaining sites. There is no genetic correspondence to the 4 management units, except for eastern basin MU 4.

HARRISON, J.W. and SMITH, R.E.H., University of Waterloo, Waterloo, ON, N2L 3G1, Canada. **Intra-seasonal and Diurnal Variability of Photosynthetic Health of Nearshore Lake Ontario Phytoplankton.**

Carbon fixation by phytoplankton constitutes the base of aquatic food webs and the efficiency of this process in situ may be influenced by quality and quantity of sunlight, vertical mixing and ambient water chemistry. Intra-seasonal and diurnal variation in photosynthetic efficiency (Fv/Fm; PAM) of Lake Ontario phytoplankton was assessed for a nearshore site at depths of 0, 1, 2.5, 5, 7.5 and 10m from May – Oct. 2008. The study area is ~2 km from a highly urbanized shoreline (Pickering) and heavily colonized by dreissenid mussels. Data on inorganic nutrient concentrations, irradiance, thermal structure, and community composition were collected. Values of Fv/Fm ranged from optimal (0.72) to severely inhibited (0.08). Fv/Fm was

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

generally depth-dependent (increasing with depth) reflecting the attenuation of damaging ultraviolet radiation. Solar irradiance also explained most of the diurnal variation per depth (i.e. low midday Fv/Fm with strong late-afternoon recovery). Laboratory incubations showed high sensitivity to UVB radiation, mild sensitivity to UVA and negligible negative influence of visible light. Inorganic nutrient availability and shifts in taxonomic composition may explain intra-seasonal variation in Lake Ontario phytoplankton photosynthetic efficiency.

Keywords: Ultraviolet radiation, Photosynthesis, Phytoplankton.

HART, D.A.¹ and KANIA, P.A.², ¹Univ. of Wisconsin Sea Grant, Madison, WI, 53706; ²Perkins High School, Sandusky, OH. **GEE: A Partnership for Google Earth in Education.**

In Summer 2008, teachers and nonformal educators from Ohio and Wisconsin joined a technology-based curriculum development and evaluation class offered at Stone Lab. GIS specialist David Hart and his high school son Noah demonstrated for the teachers the possibilities that Google Earth offers for enhancing curriculum. Over the course of the week, teachers selected Great Lakes regional topics, many from traditional formats, and explored how to convert them to interactive Google Earth applications. Topics included erosion on Lake Erie, the sinking of the Edmund Fitzgerald, water quality in Old Woman Creek, songbird migration, a virtual field trip along the Olentangy River, and comparison of fresh and salt water fish. In this session, we'll explain how the partnership between scientist and teachers was developed, and Pat Kania, one of the teachers in the class, will demonstrate how he has built upon the partnership. His curriculum website is becoming a source for posting the new applications.

Keywords: Education, GIS, Great Lakes basin.

HARTZOG, P.E.¹, HERSHEY, K.M.¹, NIMS, M.K.¹, NORMAN, S.A.², POPE, A.J.⁴, and WINSLOW, C.J.³, ¹The Ohio State University, 484 West 12th Avenue, Columbus, OH, 43210-1292; ²Wittenberg University, Post Office Box 720, Springfield, OH, 45501; ³Bowling Green State University, 217 Life Sciences Building, Bowling Green, OH, 43403; ⁴Illinois Natural History Survey, Kaskaskia Biological Station, Sullivan, IL, 61951. **Activity Monitoring of Round Goby (*Apollonia melanostomus*) in Lake Erie.**

In order to predict the consequences of exotic introductions, we must first attempt to identify mechanisms through which native and invasive species coexist. Past laboratory trials and mesocosm experiments have suggested that young-of-the-year smallmouth bass (*Micropterus dolomieu* - YOYSMB), post egg yet pre-piscivorous, experience interference competition with round goby (*Apollonia melanostomus* - RG). RG push YOYSMB into the water column away from preferred benthic prey and shelter. This vertical movement results in decreased YOYSMB growth rate and increases risk of predation. However, in order for interference competition to impact YOYSMB in the wild both RG and YOYSMB need to be active at the same time. Unfortunately, RG movement in Lake Erie is poorly documented. Therefore, our study used daytime video recordings (dawn, mid-day, dusk), night and day SCUBA observations, and a 24-hour measure of gut fullness as a surrogate measure of activity. RG showed increased movement at dawn and dusk relative to mid-day, are 255% more active during daylight relative to night, and show peak gut fullness between 0700 and 1900. Our study

reveals that the activity of RG in Lake Erie is synchronized with smallmouth bass activity supporting the potential for reduced growth rate and an increased risk of predation in the presence of RG. *Keywords: Lake Erie, Behavior, Round goby.*

HATT, C.R., Michigan Tech Research Institute, 3600 Green Court, Suite 100, Ann Arbor, MI, 48105. **Application and Evaluation of Two Satellite-Derived Bathymetry Algorithms for Clear Shallow Inland Lakes.**

Two algorithms used to produce depth maps from multi-spectral remote sensing satellite imagery were adapted and evaluated for use in the clear, shallow lakes found on the North Slope of Alaska, also applicable to lakes in the Great Lakes basin. The low turbidity and shallow depth of these lakes are ideal properties for these algorithms. The algorithms were adapted from the so-called “linear” approach developed by Lyzenga (1978) and the “ratio” approach developed by Stumpf, Holderied, and Sinclair (2003). The linear approach derives water depth from a linear combination of the log-transformed radiance at different bands, while the ratio approach derives water depth by scaling and offsetting the ratio of the natural log of two bands. In-situ bathymetry data was collected with BathyBoat, a remote controlled robot buoy that collects depth data along with GPS location data. The in-situ data was used to determine the algorithm coefficients for a given lake. The variability of the coefficients between lakes was compared in order to estimate the ability to use the algorithm in lakes without collecting in-situ data. Correlations between in-situ and satellite depth were high when in-situ data was used to calculate the algorithm coefficients for that specific lake, and accuracy decreased when coefficients from another lake were used. *Keywords: Remote sensing, Risk assessment, Assessments.*

HAWLEY, N. and EADIE, B.J., Great Lakes Environmental Research Laboratory, 4840 S. State Road, Ann Arbor, MI, 48105. **Under-ice Physical Conditions in Lake Erie during the Winter of 2004-2005.**

Time series observations of water temperature, turbidity, current velocity, and wave action were made at two stations in Lake Erie during the winter of 2004-2005. The water depth at the station located in the central basin was 25 m, and the depth at the station in the eastern basin was 53 m. Sequencing sediment traps were also deployed 5 m above the bottom at both stations; samples were collected over 9 day intervals. Ice cover began in late January 2005 and continued until late March. Most of the central basin was covered by ice throughout this period, but the eastern basin remained largely ice-free until early March. Wave action and sediment resuspension were inhibited throughout the period of ice cover and the mass flux measured by the sediment traps declined to very low levels, indicating that suspended material was cleared from the water column. The presence of ice did not seem to have affected the currents, however, which show little variation in either speed or direction. *Keywords: Lake Erie, Ice, Sediment transport.*

HE, C.¹, DEMARCHI, C.², CROLEY, T.E.³, and JOHNGEN, T.H.⁴, ¹Department of Geography, Western Michigan University, 3234 Wood Hall, Kalamazoo, MI, 49008-5424;

²Department of Geological Sciences, Case Western Reserve University, 10900 Euclid Ave, Cleveland, OH, 44106-7216; ³NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48108-9719; ⁴School of Natural Resources and Environment, University of Michigan, 440 Church St., Ann Arbor, MI, 48109-1041. **Developing a Distributed Watershed Hydrology, Sediments Load, and Nutrients Load Model for Saginaw Bay.**

Nutrient loadings from drainage basins constitute one of the primary stressors affecting coastal waters in the Great Lakes and elsewhere. Strategies for decreasing such loads involve managing hundreds of point sources and possibly thousands of nonpoint sources. Therefore, as part of the Adaptive Integrated Framework project for managing the effects of multiple ecosystem stressors on the water quality and food webs of Saginaw Bay, Lake Huron, we are developing a distributed watershed hydrology and pollutant loading model based on the Distributed Large Basin Runoff Model (DLBRM). We calibrated and verified the hydrological component of the DLBRM at 1km and 500m resolution with excellent results. The water quality module is based on detailed surveys of point and nonpoint pollution sources, on an adaptation of the Revised Universal Soil Loss Equation for continuous daily simulation, and on linear models for in-stream water quality processes. Calibration of the model takes advantage of the data gathered in 2008 by an extensive sampling of water quality in key points of the Saginaw River watershed. *Keywords: Sediment load, Nutrient load, Lake Huron.*

HEAD, J.A.¹, DEBOFSKY, A.¹, and BASU, N.², ¹Cooperative Institute for Limnology and Ecosystems Research, University of Michigan, 440 Church Street, Ann Arbor, MI, 48109; ²School of Public Health, University of Michigan, 109 S. Observatory Street, Ann Arbor, MI, 48109. **Interactive Effects of Methyl Mercury and Hypoxia in Great Lakes Fish.**

The goal of this research is to evaluate interactive effects of two stressors of concern to Great Lakes fish populations; episodic exposure to hypoxia, and methyl mercury contamination. Although mercury and hypoxia commonly co-occur in aquatic ecosystems, interactive effects on fish have not been studied. To address this question, we have we have established an experimental protocol for assessing fish exposed to multiple stressors in a laboratory setting. Here, fathead minnows were exposed to environmentally relevant concentrations of dietary methyl mercury (0, 1, or 4 ppm) for 3 weeks followed by a 1 week hypoxic challenge. We evaluate the effect of exposure to hypoxia on the accumulation and distribution of methyl mercury in fish. *Keywords: Fish, Methylmercury, Hypoxia.*

HEDGES, K.J., MANDRAK, N.E., KOOPS, M.A., and JOHANNSSON, O.E., Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **GAP Analysis in the Great Lakes: The Ins and Outs of Aquatic Protected Areas.**

Aquatic Protected Areas (APAs) are used extensively in the management of large lakes, including all of the Laurentian Great Lakes. Several different types of APAs exist within the Great Lakes, including sites that protect only habitats, locations that limit or prevent species exploitation and areas where both habitats and species are protected. Great Lakes APAs have

typically been established with a specific conservation or management target, focusing on a specific habitat feature or species, though protection can be realized by non-target habitats or species. To determine the fish species and habitats that are currently protected and those that currently receive no protection within the Great Lakes a GAP analysis was conducted using GIS data regarding locations and types of APAs, habitat variables, species distributions and anthropogenic activities. Species and habitats falling within APAs with applicable restrictions were identified as receiving protection and the proportion of the area protected within the Great Lakes for a species or habitat type was quantified (e.g. sum of areas within which a habitat is protected/total area of that habitat within the Great Lakes). Analyses were conducted within individual lakes and within the Great Lakes as a whole. *Keywords: Ecosystems, Refugia, Lake management.*

HENSLER, S.R. and JUDE, D.J., University of Michigan, School of Natural Resources and Environment, 440 Church St., Ann Arbor, MI, 48109-1115. **Recruitment Bottlenecks for Walleye in the Muskegon River Estuary, Lake Michigan.**

Larval walleye were collected weekly spring 2003-04 using plankton nets in the lower Muskegon Estuary. In 2003 we sampled 13 stations from Croton Dam to Lake Michigan. In 2004, we concentrated on Muskegon Lake. No walleye larvae were collected in 2003 and they were rare in 2004, despite estimated spawning runs around 50,000 adults. Larval walleye appeared over 4-24 May. In the lake, walleye larvae were collected 14 times and ranged from 2 to 82 individuals/1,000 m³. Walleye larvae were more common near the river inlet and middle of Muskegon Lake. Mean growth was 0.6 mm/day 10-17 May and 0.2 mm/day 17-24 May. During 1986 (Day 1991) and 2004, we estimated 913,032 and 149,830 larval walleyes respectively were found in the Muskegon River. We estimated 11,685-81,841 larval walleyes occurred in Muskegon Lake over the three dates. Survival rates from egg to larvae were 0.00002 - 0.002. Otoliths revealed all walleye larvae were 1-2 day old, and since hydraulic studies showed a particle at the dam would take 2 days to reach Muskegon Lake, we concluded most walleyes hatched below the dam died. Walleye recruitment may be depressed by egg destruction due to high currents/cold temperatures in the area below Croton Dam. Flow manipulation during spawning and alternative stocking methods may improve walleye recruitment. *Keywords: Lake Michigan, Fish, Recruitment.*

HERMANSON, J.C.¹, PEYER, S.M.², and JOHNSON, J.A.³, ¹Forest Products Laboratory, One Gifford Pinchot Drive, Madison, WI, 53726; ²University of Wisconsin, 421 Birge Hall, 430 Lincoln Dr, Madison, WI, 53706; ³University of Washington, Box 352100, Bloedel 303, Seattle, WA, 98195-2100. **Using the Inverse Problem Methodology in Biology.**

As the session synopsis duly states, 'invasion biology is still reactive rather than proactive.' In order to become proactive, biologists will need to establish and validate meaningful models that predict new invasions. The "inverse problem" is an emerging tool in physics and engineering that is concerned with establishing and validating physical models based upon observed data. The objective of this presentation is to illustrate how biologists can incorporate the inverse problem methodology into establishing and validating models that will enable them

to become proactive. After a brief overview of inverse problem theory, we show an example which calculates the hydrodynamic lift coefficients of zebra and quagga mussels. For input into the inverse problem, we used the observed probability of failure, which is the ratio of the mussels that detached (failed) to those that stayed attached (success) in flow, and the mussel's detachment strength when subjected to being pulled off via a mechanical test machine. The inverse problem yielded lift coefficients consistent with other species of bivalves that were determined by traditional experimental techniques in which lift force was measured directly. Our results showed that zebra mussels have a more streamlined profile than quagga mussels. *Keywords: Model testing, Model studies, Zebra mussels.*

HICKS, R.E.¹, OSTER, R.J.¹, OSTROM, D.E.¹, KISH, J.L.¹, WELCH, J.¹, BOOTH, C.², and WERNE, J.P.², ¹Department of Biology, University of Minnesota Duluth, Duluth, MN, 55812; ²Large Lakes Observatory and Department of Chemistry and Biochemistry, University of Minnesota Duluth, Duluth, MN, 55812. **Abundance and Diversity of Planktonic Ammonia-Oxidizing Archaea in Lake Superior.**

Nonthermophilic Archaea have previously been reported in great lakes worldwide but their ecological roles remained unknown. The ability to oxidize ammonia, an important process in the nitrogen cycle, was thought until recently to be restricted to a few groups of Bacteria. We investigated the abundance and diversity of ammonia-oxidizing Archaea (AOA) from various water depths at an offshore site in Lake Superior. Although dissolved ammonia (typically <0.2 μ M) and nitrification rates (<4 ng C/L•h) were usually low, a putative archaeal ammonia monooxygenase gene (*amoA*) was repeatedly amplified by PCR from 2006 to 2008. This archaeal gene was found in greatest concentration (10^6 to 10^7 copies/L) within the hypolimnion during stratified conditions and at much lower levels (10^3 to 10^5 copies/L) in the epilimnion and throughout the water column during mixed lake conditions. Thirteen archaeal *amoA* clones obtained from the upper hypolimnion (30 and 40 m) during the summer were most similar to a 'low salinity cluster' of archaeal *amoA* clones from brackish sediments in San Francisco Bay. This study extends previous information about planktonic Archaea in Lake Superior by providing clear evidence for the existence of AOA, and suggests some Archaea play a significant role in the nitrogen cycle of great lakes. *Keywords: Microbiological studies, Biogeochemistry, Lake Superior.*

HIGGINS, S.N. and VANDER ZANDEN, M.J., Center for Limnology, 680 N. Park St., Madison, WI, 53706. **The Cascading Ecological Effects of Dreissenid Mussel Invasions on Lake and River Ecosystems.**

The invasion of North American and European freshwaters by dreissenid mussels has resulted in profound changes to the biogeochemistry, flora, and fauna of these ecosystems. With the exception of a few studies, most investigations on the impact of dreissenid mussels have focused on the biogeochemistry or a small number of taxa in a single ecosystem. In this study we have reviewed >500 peer reviewed articles, grey literature, and long-term monitoring data. Our dataset contains >50 lakes including 4 Laurentian Great Lakes, 9 rivers, and 18 microcosm/mesocosm experiments. Dreissenid mussel invasion has been accompanied by, on

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

average, a 30-45% decline in suspended solids, a 30-70% increase in transparency, a 40-80% decline in phytoplankton biomass, a 40-75% decline in zooplankton biomass, a 2000% increase in sediment associated bacteria near dreissenid beds, a 170-180% increase in periphyton and macrophyte biomass, a 150-200% increase in non-dreissenid zoobenthic biomass within littoral habitats, and a 50% decline in non-dreissenid zoobenthic biomass within profundal habitats. Our results indicate the role of dreissenids in dramatically altering the flow of energy and nutrients from pelagic to benthic zones, with significant effects on the biogeochemistry, flora and fauna of lake and river ecosystems. *Keywords: Dreissena, Ecosystems, Invasive species.*

HILL, R.B., Environment Canada, 867 Lakeshore Road, Burlington, ON, L7L 6V7, Canada.
Contaminants in the Niagara River: Two Decades of Upstream/Downstream Monitoring.

As part of the Niagara River Toxics Management Plan, a formal monitoring program was established on the Niagara River using an upstream station at Fort Erie and a downstream station at Niagara-On-The-Lake. The primary purposes of the “Upstream/Downstream Program” were to establish the existence and relative concentrations of contaminants, distinguish between Niagara River contaminant sources and upstream sources, to identify exceedences to existing water quality criteria, and to quantify loadings of these contaminants to Lake Ontario. Data from the Upstream/Downstream program were analyzed over the 19 year period from 1986/87 to 2004/05 to determine trends in both annual mean concentrations and loads. Results show a significant decrease in concentration for most compounds but there are still some compounds which exceed the strictest agency water quality criteria. Analysis also shows that local sources continue to contribute to contaminants; however, upstream and Great Lakes basin-wide sources may be more significant for certain chemicals. *Keywords: Water quality, Environmental contaminants, Niagara River.*

HINCHEY MALLOY, E.K.¹, MILLER, B.K.², BOEHME, S.E.³, GOETTEL, R.G.², MERRIFIELD, L.², ADAMS, J.M.¹, and WALTERS, H.⁴, ¹Illinois-Indiana Sea Grant College Program, Purdue University, U.S. Environmental Protection Agency Great Lakes National Program Office, Chicago, IL, 60604; ²Illinois-Indiana Sea Grant College Program, 1101 West Peabody Drive, MC635, Urbana, IL, 61801; ³Illinois-Indiana Sea Grant College Program, University of Illinois, U.S. Environmental Protection Agency Great Lakes National Program Office, Chicago, IL, 60604; ⁴Ashland University, 401 College Avenue, Ashland, OH, 44805.
Climbing the Evaluation Pyramid: Techniques used by Illinois-Indiana Sea Grant to evaluate Outreach Programs.

In light of a tightening economy, fewer funding opportunities, and shrinking budgets for governmental services, it is imperative to demonstrate that the impact from a program effort is greater than its cost. The Sea Grant College program uses the Bennett concept of “Hierarchy of Effectiveness” indicators to plan and evaluate extension programs to increase their effectiveness. Basically, the concept outlines different levels of performance indicators. As programs mature, the types of results and impacts made are expected to move up a hierarchical pyramid. Short-term outcomes will be toward the bottom, mid-term outcomes will usually be toward the middle, and long-term outcomes will most likely be toward the top of the pyramid. Projects and

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

programs should strive to design programs to achieve higher level impacts. This talk will provide examples of Illinois-Indiana Sea Grant Extension programs that fit different categories in the hierarchy of performance indicators, and will also discuss the evaluation instrument and methods we used at each level and the impacts that resulted. Examples to be highlighted include a COSEE Great Lakes week-long workshop, Local Decisionmaker, unwanted medicine take-back programs, Planning with Power, and Great Lakes Legacy Act sediment clean-up projects.

Keywords: Education, Outreach, Evaluation.

HINCHEY MALLOY, E.K. and ADAMS, J.M., Illinois-Indiana Sea Grant, Purdue University, 77 W. Jackson Blvd. G-17J, Chicago, IL, 60604. **Bringing the Great Lakes into the Classroom: Examples of COSEE-inspired Science Learning Environments.**

The COSEE Great Lakes *Shipboard and Shoreline Workshops* provide unique opportunities for educators and scientists to spend a week at sea together, working side-by-side as the *R/V Lake Guardian* traverses the Great Lakes. In this session, a team of teachers and scientists will present examples of science lessons that originated from our involvement in the COSEE workshops and have been used in high school classrooms and science centers. Examples include The Incredible Shrinking Cup Lab, creation of a water quality monitoring after-school program, an *R/V Lake Guardian* blog site, and more! *Keywords: Education, COSEE, R/V Lake Guardian.*

HITES, R.A., VENIER, M., and BASU, I., Indiana University, SPEA Room 410 H, Bloomington, IN, 47405, United States. **Spatiotemporal Analyses of Integrated Atmospheric Deposition (IADN) Network Data.**

IADN has measured the vapor phase conc. of >100 compounds in atmospheric samples collected at 5 U.S. sites for 16 years. How do we explain the variability in these conc. to determine spatial and temporal trends? We know that atmospheric partial pressures (P) of these contaminants are a function of atmospheric temperature (T) and of the human population, expressed as log(POP), living and working within a 25 km radius of the sampling site. It is also good to know if the conc. of these compounds are decreasing as a function of time (expressed as Julian Days, JD, from 1/1/1990). To determine the relative importance of these 3 factors, we have combined them into a multiple regression of the form: $\ln(P) = a_0 + a_1(JD) + a_2/T + a_3 \log(POP)$. Each parameter is associated with a sum of squares that indicates its importance in the overall regression. For the time parameter (a_1), only γ -HCH shows a large effect. For the temperature parameter (a_2), α -HCH, Σ DDT, Σ endosulfans, and Σ chlordanes show large effects. For the population parameter, (a_3), Σ PCB, Σ PAH, Σ DDT, and Σ chlordanes show large effects. These results suggest that PCBs are not going away anytime soon; that α -HCH (but not γ -HCH) is disappearing rapidly; and that DDT has both agricultural and urban sources. *Keywords: PCBs, Pesticides, PAHs.*

HOLECK, K.T.¹, MILLS, E.L.¹, RUDSTAM, L.G.¹, SCHULZ, K.L.², and O'GORMAN, R.³,
¹Cornell University Biological Field Station, 900 Shackelton Point Rd., Bridgeport, NY, 13030;

²SUNY College of Environmental Science and Forestry, Illick Hall, 1 Forestry Drive, Syracuse, NY, 13210; ³USGS Lake Ontario Biological Station, Oswego, NY, 13126. **Zooplankton as Indicators of Ecosystem Change in Lake Ontario.**

Managing the Lake Ontario resource using an ecosystem approach requires the monitoring of ecological indicators to gain insight about the status of other ecosystem components. Zooplankton have traditionally been considered good indicators due to their intermediate position in the food web; they respond to changes occurring both in nutrient levels and planktivorous fish populations. We examine a long-term dataset from Lake Ontario to determine the utility of zooplankton as indicators of ecosystem change in relation to declines in phosphorus, establishment of dreissenid mussels, alewife abundance, shifts in alewife distribution, the presence of the fish-hook flea, *Cercopagis pengoi*, and the presence of the spiny water flea, *Bythotrephes longimanus*. The dataset includes spatially distinct nearshore and offshore sites and covers the period from 1984 to 2007, a time span in Lake Ontario that includes a shift toward a more oligotrophic state, a general decline in alewife abundance, a rise in dominance of quagga mussels, seasonal pulses of *Cercopagis*, and sporadic spikes of *Bythotrephes*. *Keywords: Bioindicators, Lake Ontario, Zooplankton.*

HOLSEN, T.M.¹, HOPKE, P.K.², AMOS, M.M.³, MILLER, K.M.³, MILLIGAN, M.S.⁴, MURPHY, E.W.⁵, PAGANO, J.J.⁶, and SCOFIELD, J.A.³, ¹Clarkson University, Dept. of Civil and Environmental Engineering, Potsdam, NY, 13699; ²Clarkson University, Dept. of Chemical Engineering, Potsdam, NY, 13699; ³Computer Sciences Cooperation, 6101 Stevenson Avenue, Alexandria, VA, 22304; ⁴SUNY Fredonia, Department of Chemistry, Fredonia, NY, 14063; ⁵S. EPA Great Lakes National Program Office, 77 W. Jackson Blvd., Chicago, IL, 60604; ⁶SUNY Oswego, Environmental Research Center, Oswego, NY, 13126. **Relationships among Legacy and Emerging Contaminant Concentrations in Great Lakes Fish between 1999 and 2005 and Evaluation of Site-specific Differences.**

The Open Lakes Trend Monitoring Program element of the Great Lakes Fish Monitoring Program was designed to monitor contaminant trends in the open waters of the Great Lakes and assess the overall effects of toxics on fish and fish consuming wildlife. Project data spanning 1999-2005 were evaluated to assess the relationships among contaminant concentrations in whole top predator species in the Great Lakes. Relationships among emerging and legacy contaminants, including PBDE and PCB congeners, mercury, and pesticides, were evaluated on a site-specific basis using correlations and other statistical measures of association. A subset of 38 of these contaminants was subjected to a series of regression analyses to identify temporal and spatial patterns and trends and to identify potential relationships between sources and concentration. Some of these contaminants are deposited atmospherically into the watersheds, ingested by microorganisms, and eventually incorporated into the diet. Sources of contaminants and pathways into the food web vary by lake and impact the observed fish tissue contaminant concentrations. Evaluation of relationships among the contaminants and differences among the sampling sites provides clues to identifying the sources and pathways of these contaminants to Great Lakes fish. *Keywords: Correlation, Chemical analysis, Fish.*

HOLUB, B., University of Guelph, Guelph. **Omega-3 Fatty Acid Contents of Great Lakes Fish.**

Much interest has arisen recently on the health benefits of consuming higher amounts of the long-chain omega-3 fatty acids known as DHA (docosahexaenoic acid) and EPA (eicosapentaenoic acid) in support of optimal neuronal and visual functioning, as well as reducing the risk of sudden cardiac death. Marine-based fish and seafoods are well regarded as rich sources of DHA/EPA. With support via the International Joint Commission's Health Professionals Task Force, the omega-3 contents (DHA/EPA) plus other fatty acids present in selected fishes from the Great Lakes will be presented. The compositions are derived partly from results previously published plus very recent analyses conducted during 2009 at the University of Guelph Research Park via high-performance capillary gas-liquid chromatographic technology. It is apparent that fish from the Great Lakes are generally a rich source of DHA/EPA, which is of potential importance to both the commercial fisheries sector and the public.

Keywords: Metabolism, Environmental contaminants, Fish.

HONEYFIELD, D.C.¹, TILLITT, D.E.², and FITZSIMONS, J.D.³, ¹US Geological Survey, 176 Straight Run Road, Wellsboro, PA, 16901; ²US Geological Survey, 4200 New Haven Road, Columbia, MO, 65201; ³Department of Fisheries and Oceans, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Thiamine Deficiency in the Great Lakes and Elsewhere: a Symptom of Unhealthy Ecosystem.**

Reproductive failure of salmonid species in the Great Lakes, referred to early mortality syndrome (EMS), was first observed in the late 1960s from an unknown cause. In the early 1990s incidence of fry mortality dramatically increased such that hatcheries could no longer compensate by increasing egg take. The same was true in Cayuga Lake, NY and the Baltic Sea syndrome (M74). Subsequently, we found that fry mortality was caused by thiamine deficiency linked to consumption of thiaminase containing prey. M74 in the Baltic Sea, Cayuga syndrome in NY and EMS in the Great Lakes were all caused by thiamine deficiency. The problem was not due to low intake of this essential vitamin, but its destruction. Furthermore thiamine deficiency was affecting adults and the deficiency was associated with secondary affects (immune function, prey capture, growth, gene expression). We have evidence of thiaminase in net plankton, altered food webs with non-native species, as well as observations of anthropogenic alterations. Therefore it seems that no better case for ecosystem dysfunction can be made than when its predatory inhabitants are suffering varying degrees of beriberi. Thus thiamine deficiency is a symptom of an unhealthy ecosystem. *Keywords: Ecosystem health, Vitamin B, Fisheries.*

HOOD, J.L.A.¹, ANDERSON, M.², and TAYLOR, W.D.¹, ¹University of Waterloo, 200 University Ave W, Waterloo, ON, N2L3G1; ²Grand River Conservation Authority, 400 Clyde Road, Cambridge, ON, N1R5W6. **Spatial Survey of Submersed Macrophytes and Macroalgae in the Grand River Watershed.**

Macrophytes and macroalgae are important components of the riverine tributaries to the Great Lakes, and can often reach nuisance levels of biomass, causing depressed dissolved

oxygen conditions, clogged pipes and waterways, and creating poor habitat for fish. Controlling macrophyte biomass has been an interest for resource managers for several decades, although the factors leading to nuisance levels of biomass are still a subject of scientific uncertainty. Most agree that excess nutrient loading is responsible for increases in biomass, however, empirical evidence for nutrient-biomass relationships in rivers is not strong. Rivers are very heterogeneous environments, and the spatial aspect of a riverine system is important to consider for developing an understanding of benthic communities. Spatial patterns may be overlooked or not considered when designing sampling programs, or an incorrect sampling scale may be used, which can obscure significance empirical relationships. Here we present multi-year spatial data on submersed macrophytes in the Grand River watershed and demonstrate that inclusion of spatially relevant data can yield a better understanding of benthic plant communities and their relationship between plant biomass and nutrient loading point sources. *Keywords: Watersheds, Cladophora, Nutrients.*

HORIE, T.¹, HOMANS, F.R.², HAIGHT, R.G.³, and VENETTE, R.C.⁴, ¹Department of Applied Economics, University of Minnesota, 1994 Buford Avenue, St. Paul, MN, 55108; ²Department of Applied Economics, University of Minnesota, 1994 Buford Avenue, St. Paul, MN, 55108; ³Northern Research Station, US Forest Service, 1992 Folwell Avenue, St. Paul, MN, 55108; ⁴Northern Research Station, US Forest Service, 1561 Lindig Street, St. Paul, MN, 55108.

Optimal Strategies for Surveillance and Control of Invasive Forest Pathogens.

The most effective strategy for limiting the spread of invasive forest pathogens such as oak wilt is to find and remove affected trees. The detection step is an important one, because trees must be specifically identified as being diseased before being removed; broadcast aerial spraying, for example is not an option for control of fungi. However, there has generally been little attention paid to the problem of determining how much effort should be devoted to detection of invaders. We use a mixed integer programming approach, inspired by the site selection literature, to choose locations in a grid on which to focus detection and control efforts in a budget-constrained setting. Locations vary by the number of susceptible trees, the number of infected trees, the infection rate, and the cost of tree removal. One version of our model allows us to characterize each site by a distribution, rather than a known quantity, of the number of infected trees. We apply our model to the case of Anoka County, Minnesota, a county with a severe oak wilt problem. We use our model to determine which sites within Anoka County should be given highest priority for inspection and removal. Our model is adaptable to other locations for which oak wilt is a potential problem. *Keywords: Biological invasions, Urban forest, Site selection.*

HORN, J.D., SATHYANARAYAN, A., and CULVER, D.A., The Ohio State University, EEOB, 1315 Kinnear Road, Columbus, OH, 43212. **Using EcoLE-FisH to Examine Percid Recruitment and Management in Lake Erie.**

Great Lakes piscivore populations and fisheries present numerous challenges to managers, whose decisions often elicit strong responses from fishermen. We have used EcoLE-FisH, a two-dimensional length-depth mathematical model of Lake Erie built upon the U.S.

Army Corps of Engineers' CE-QUAL-W2 framework, to simulate the impacts of management decisions on walleye (*Sander vitreus*) within Lake Erie. EcoLE-FisH incorporates the dynamics of Lake Erie's physical, chemical, and lower trophic level components, as well as that of young-of-year and adult walleye plus fishing management to explore walleye recruitment and population dynamics. Human interactions with walleye are modeled through the sport fishing process and the management of the fishable walleye population. Coupling the physical, nutrient and lower trophic levels with the walleye recruitment and adult mortality processes allows us to capture the spatial and temporal trends in walleye abundance variability, while the simulation of the fishing and management processes enables us to investigate the drivers of fishing mortality throughout Lake Erie. Our simulations suggest that natural physical processes (e.g., winter temperature) may affect the recruitment of young-of-year walleye populations more than does variation in springtime zooplankton forage in the western basin. *Keywords: Model testing, Lake Erie, Percids.*

HORST, G.P. and SARNELLE, O., Department of Fisheries and Wildlife, Michigan State University, East Lansing, MI, 48824. **Phosphorus Uptake Physiology of *Microcystis* and Competing Taxa along a Nutrient Gradient in Western Lake Erie.**

To better understand how algal populations compete for phosphorus, we compared multiple components of the nutrient physiology of the toxic cyanobacterium *Microcystis* versus the rest of the competing algal community at 6-10 stations within the western basin of Lake Erie during 2006-2008. One indication of phosphorus limitation, alkaline phosphatase activity (APA), was higher for *Microcystis* at stations with low total phosphorus (TP), but negligible for the rest of the phytoplankton at most stations. Phosphorus uptake capacity for all taxa was also inversely proportional to ambient TP conditions. Interestingly, *Microcystis* had up to 4 times higher uptake capacity (per biomass) than the competing algal community at many stations. Large nutrient pulses from the Maumee River were detected during each sampling season from May through October, characterized by TP concentrations varying by more than 100% at some stations within a span of 2-3 weeks. While it is well-known that cyanobacteria are competitively inferior under static and low ambient phosphorus conditions, our results suggest that *Microcystis* may have a phosphorus uptake physiology adapted to pulsed nutrient conditions and this may help to explain its success at low to moderate phosphorus levels in areas of the western basin.

Keywords: Harmful algal blooms, Lake Erie, Nutrients.

HOUGHTON, C.J. and JANSSEN, J., WATER Institute, UW-Milwaukee, 600 East Greenfield Ave., Milwaukee, WI, 53204. **Change in Habitat Selection by Juvenile Yellow Perch in Response to the Round Goby Invasion.**

Lake Michigan yellow perch encounter round gobies at the beginning of their nearshore demersal phase. Both species share a preference for rocky habitat creating a situation where competitive interactions will occur. Previous research has shown that round gobies decrease densities of benthic arthropods, the primary prey of YOY yellow perch, and may have a negative impact on yellow perch populations. We examined habitat selection and dietary composition of YOY yellow perch using paired (sandy vs. rocky substrates) gill-net sets along the Wisconsin

coast during the late summers of 2005-2007. Gill netting data showed a statistically significant negative correlation between percent of YOY yellow perch collected on rocky habitat and round goby catch per effort ($r=-0.83$, $P < 0.001$, 10 df). Stomach content analysis showed Large (>70mm) YOY yellow perch with multiple YOY round gobies in their stomachs, the recently invaded *Hemimysis anomala* was also found in perch stomachs. It is not yet known what effects the transition to sandy substrates, and introduction of these new prey options, will have on yellow perch in Lake Michigan. *Keywords: Invasive species, Fish, Lake Michigan.*

HOWELL, T.¹, YERUBANDI, R.², LOOMER, H.³, and RICHARDSON, V.², ¹Ontario Ministry of the Environment, 125 Resources Road, Toronto, On, M9P 3V6; ²Environment Canada, 867 Lakeshore Road, Burlington, On, L7R4A6; ³Grand River Conservation Authority, 400 Clyde Road, Cambridge, On, N1R 5W6. **Water Quality in the Nearshore of the Central Basin of Lake Erie Adjacent to the Mouths of Kettle, Big Otter and Catfish Creeks.**

The mixing areas near mouths of tributaries are zones of variability in water quality in the nearshore of the lower Great Lakes owing to the typical disparity in character between river water and the open lakes. In 2007 approximately 40 km of shoreline of the central basin of Lake Erie were studied to assess environmental conditions and to investigate anthropogenic and natural factors contributing to the dynamic in water quality over the region. Focal points for surveys were mouths of three mid-sized rivers draining a rural landscape with some smaller communities. A spatially-oriented survey design was used to map nutrients, fecal pollution indicators, and physical features within the nearshore. Tributaries were monitored throughout the study. Time series of measurements from a network of sensors (ADCPs and temperature strings) provided information on lake circulation. Variability in conditions occurred on mixed temporal and spatial scales. There were strong seasonal and episodic changes in volume and quality of tributary discharge and differences in water chemistry among tributaries suggestive of variability in geology and land use. Variable land-to-lake mixing areas, coastal processes and nearshore-offshore dynamics created a mosaics of condition on scales ranging from locally at the shoreline to the entire nearshore zone. *Keywords: Monitoring, Water quality, Lake Erie.*

HSIEH, Y.F.¹, LIAO, Q.², and WU, C.H.¹, ¹1269D Engineering Hall, 1415 Engineering Drive, Madison, WI, 53706; ²E363 Department of Civil Engineering and Mechanics, 3200 North Cramer Street, Milwaukee, WI, 53211. **Boundary Mixing in the Thermocline of a Stratified Lake.**

Boundary mixing is of great importance for chemical and biological processes in stratified lakes since its intensity is typically orders of magnitude larger than internal mixing. Main mechanisms leading to boundary mixing in the thermocline include (i) shear-induced periodic up- and down- slope currents of internal seiche and (ii) breaking of high-frequency shoaling internal waves. To quantify the boundary mixing, we conducted extensive field measurements in a stratified lake, Lake Mendota. An in situ underwater particle image velocimetry (UWPIV) technique was applied to obtain vertical distribution of instantaneous velocities right above the water-sediment interface, and to estimate the near-bed turbulent kinetic energy and dissipation rate. An acoustic Doppler velocimeter was used to measure high temporal

velocities close to the bottom to estimate dissipation rates. Two acoustic Doppler current profilers (ADCP) and hundreds of thermistors were moored to record the current and temperature structures through the whole water column along a sloping bottom. Results of these measurements are reported to address the role of boundary mixing in the thermocline.

HU, D. and HORNBUCKLE, K.C., Department of Civil and Environmental Engineering, IHR-Hydroscience and Engineering, Iowa City, IA, 52242. **PCBs in Commercial Paint Pigments.**

Non-Aroclor PCB (3, 3'-dichlorobiphenyl or PCB11) was discovered in our air samples collected in Chicago Illinois in 2007. PCB11 is the fifth highest congener and ubiquitous in Chicago air. We hypothesize that the extensive distribution of PCB11 is due to volatilization from painted surface. Coating paint is widely used for attractive colors and/or for protection from weathering damages. PCBs were added to paint for various reasons including water and chemical resistance in history before the cease of PCBs production. Although the airborne PCB11 is very likely from old paint applied before and around 1977, in this study we attempted to measure PCBs in currently used paint. It is impossible to detect PCBs in thousands of paint products that are commercially available in market. The raw materials, pigments, are used to impart color in paint products, and we suspect PCBs are in pigments based on the paint manufacturing process. Therefore, commercial pigments were purchased from main paint stores such as Sherwin Williams, Pittsburgh Paint, etc. The pigment samples were analyzed for all 209 PCB congeners using gas chromatography with tandem mass spectrometry (GC-MS/MS). Preliminary results indicate that some light-chlorinated PCBs including PCB11 are present in pigments. Detailed results and analysis will be presented. *Keywords: Environmental contaminants, PCBs.*

HU, H.¹ and WANG, J.², ¹CILER, University of Michigan, Ann Arbor, MI, 48108, US; ²Great Lakes Environmental Research Laboratory, NOAA, Ann Arbor, MI, 48108, US. **Modeling Sea Ice and Ocean Circulations in the Bering Sea.**

The ocean circulation and sea ice in the Bering Sea were simulated using a Coupled Ice Ocean Model. The simulated circulation in the deep basin is cyclonic with little seasonal change. The Bering Slope Current is estimated as 5 Sv, and the Kamchatka Current is estimated as 20 Sv. The Bering shelf circulation varies with seasonal winds. Sea ice begins to form in the northern Bering Sea in early November, and ice remains into June of the following year. Maximum ice cover and ice volume (about 210, 000 Km³) occurs in early April and it has a lag of two months to the lowest air temperature due to the heat capacity of the ocean. Polynyas occur downwind of the Chukchi Peninsula and St. Lawrence. Water properties in the Polynyas are featured by lower temperature, higher salinity, and higher density compared to its ambience water. The mechanism of thermocline and the cold pool formation in the middle shelf are studied, and results show that wind-mixing and tidal stirring are the main factors controlling the formation of the upper and the bottom mixed layers, respectively. With the vertical insulation by the stable thermal structure and without effective horizontal heat transport from deep basins and the inner shelf, the cold winter water is preserved in the middle shelf throughout the summer. *Keywords: Ice-ocean modelling, Bering Sea.*

HU, H.¹, WANG, J.², SCHWAB, D.J.², BELETSKY, D.¹, LESHKEVICH, G.A.², HAWLEY, N.², and CLITES, A.², ¹CILER, University of Michigan, Ann Arbor, MI, 48108, US; ²Great Lakes Environmental Research Laboratory, NOAA, Ann Arbor, MI, 48108, US. **Modeling Lake Ice and Circulation in Lake Erie.**

A 2-km coupled Great Lake Ice-circulation Model (GLIM) was implemented in Lake Erie to investigate seasonal cycles of ice and circulation under daily and hourly atmospheric forcing. The model results show that ice formation and melting are consistent with the observations. Ice cover with a maximum of 22,000 km² occurs in January and February, which is slightly higher than measurement (National Ice Center Charts). The ice drift with the wind but with a declination about 30 degree. The simulated vertical temperature structures agree with the measurements in 2004 except in the bottom layer. The circulation pattern is different in winter from in summer due to the changes of the winds and the thermal structure. *Keywords: Lake Erie, Hydrodynamic model, Ice.*

HUANG, X.L.¹ and DENG, Y.², ¹Dept. of Atmos., Oceanic, and Space Sci., 2455 Hayward St., Ann Arbor, MI, 48109-2143; ²School of Earth and Atmospheric Sciences, Georgia Institute of Technology, Atlanta, GA, 30332. **The Effect of Different Great Lakes Treatments in Simulating Winter Temperature of the Midwest: a Large-scale Modeling Perspective.**

Owing to its huge heat capacity, adequate moisture supply, and albedo change, Great Lakes play an important role in the Midwest winter temperature variations. Hence, how Great Lakes are represented in a large-scale model directly affect its capability of simulating such regional temperature properties. In this study, we analyze three NOAA GFDL GCMs, in which the treatments of lakes are significantly different while other aspects of the model are identical or similar. The standard GFDL AM2 model simply treats Great Lakes in the same manner as adjacent lands. In a modified version of AM2, Great Lakes are treated as one-layer water column with huge heat capacity. In the newly-developed AM3, Great Lakes are crudely resolved both horizontally and vertically. Climatologically, the standard AM2 has about 2K cold bias compared to the ECMWF ERA40 reanalysis. It has consistently excessive cold events but insufficient warm events, which can be at least partially explained by its treatment of Great Lakes. The modified AM2 shows a more realistic simulation. AM3, though with a more realistic treatment of lakes, bears similar deficiencies as the standard AM2. Diagnostics of regional thermodynamics further sheds light on the linkages between Great Lakes physical processes and the Midwest winter temperature variations. *Keywords: Great Lakes basin, Climates, Model studies.*

HUDDER, A.¹, O'SHEA, K.E.², DOMBKOWSKI, A.¹, and WALSH, P.J.³, ¹Wayne State University, Institute of Environmental Health Sciences, Detroit, MI, 48201; ²Florida International University, University Park, FL, 33199; ³University of Ottawa, Centre for Advanced Research in Environmental Genomics, Ottawa, ON, K1N 6N5. **Hepatic Toxicogenomic Evaluation of Microcystin-LR Exposure in Mice.**

Microcystins are a family of toxins produced by cyanobacteria and are found throughout the world in marine and freshwater environments. Humans are most often exposed to the toxin by drinking contaminated water. The toxin accumulates rapidly in the liver where it exerts most of its damage. The toxicogenomic effects of microcystin-LR were examined in mice. Animals were exposed to purified microcystin-LR by i.p. injection or inhalation. Serum was collected and assayed for lactate dehydrogenase (LDH) activity as an indicator of hepatotoxicity. LDH activity was detected in the serum of MC-LR exposed mice, but not in control mice, indicative of liver damage. RNA from a portion of the liver was used for microarray analysis and real-time PCR. Microarray analysis revealed significant changes in gene expression in response to microcystin exposure both by injection and inhalation. A subset of toxin responding genes were analyzed with real-time PCR to validate the array data. These results suggest that even low doses of microcystin-LR can have significant effects on gene expression in the target organ, regardless of route of exposure. Chronic low dose exposures over time could have a serious impact on health. *Keywords: Human health, Cyanophyta, Drinking water.*

HUNKINS, K.L.¹ and MANLEY, T.O.², ¹Lamont-Doherty Earth Observatory, Palisades, NY, 10964; ²Middlebury College, Dept. of Geology, Middlebury, VT, 5769. **A Simple Model of Wind-Driven Lake Circulation Interprets Lagrangian Drifter Observations.**

A numerical vorticity model of circulation in a rectangular basin demonstrates the contrasting roles in lake circulation of wind shear and bottom topography. In the first case the bottom is flat and wind velocity is greatest in the center of the lake. Under a symmetrical wind shear pattern a double gyre results with clockwise rotation on the right hand gyre when looking downwind. In a contrasting case wind velocity is constant but a channel profile has greatest depth at the center and shallow water near the shore. Again a double gyre develops but now the sense of rotation is reversed. An anti-clockwise gyre develops on the right. This highly simplified model is meant to aid in interpreting features of more complete models and of actual lake circulation. The model suggests a plausible explanation for the strong near-shore flow toward the south of subsurface drifting buoys during periods of steady winds from the south over Lake Champlain. *Keywords: Computer models, Atmosphere-lake interaction, Hydrodynamic model.*

ILIKCHYAN, I.N.¹, MCKAY, R.M.L.¹, ANYANWU, E.¹, BENITEZ-NELSON, C.R.², and BULLERJAHN, G.S.¹, ¹Department of Biological Sciences, Bowling Green State University, Bowling Green, OH, 43403; ²Department of Geological Sciences, University of South Carolina, Columbia, SC, 29208. **Glyphosate and Phosphonate Utilization by Freshwater Picocyanobacteria.**

Phosphonates are organic phosphorus compounds that contain a C-P bond instead of a phosphomonoester bond. Typically viewed as a recalcitrant, less bioavailable form of phosphorus, it has been recently shown that many cyanobacteria can utilize naturally occurring phosphonates as P sources. The herbicide glyphosate (Roundup) is a synthetic phosphonate, and our studies indicate that endemic picocyanobacteria can utilize glyphosate as a sole source of P. This raises the possibility that loadings of glyphosate enter the food web as a chemically distinct

form of P not accounted for by the Great Lakes Water Quality Agreement. Specifically, PCR data and growth assays reveal that all strains of pelagic *Synechococcus* spp. tested have the genetic potential to assimilate phosphonates, and most strains can utilize glyphosate. Furthermore, glyphosate is detectable by ELISA in nearshore samples from Lake Erie and Sandusky Bay. Detection coincides with the springtime application of glyphosate. In addition to glyphosate, the total phosphonate pool (likely derived from glyphosate metabolism) has been monitored by ³¹P NMR of lyophilized DOP. In particular, Sandusky Bay yields high levels of total phosphonates. The potential for glyphosate loadings to contribute to community shifts in the endemic microbial consortium will be discussed. *Keywords: Phosphonates, Glyphosate, Cyanobacteria.*

ISAAC, E.J.¹, STOCKWELL, J.D.², and HRABIK, T.R.¹, ¹University of Minnesota-Duluth, Department of Biology, Duluth, MN, 55812; ²Gulf of Maine Research Institute, Portland, ME, 4101. **Selection of *Mysis relicta* as Prey by the Lake Superior Fish Community.**

Mysis relicta is a common prey item for both benthic and pelagic fish species in Lake Superior. To evaluate how important *Mysis* are to the Lake Superior fish community, we determined the seasonal prey selectivity of cisco *Coregonus artedii*, lake whitefish *Coregonus clupeaformis*, bloater *Coregonus hoyi*, kiyi *Coregonus kiyi*, burbot *Lota lota*, deepwater sculpin *Myoxocephalus thompsoni*, rainbow smelt *Osmerus mordax*, and lake trout *Salvelinus namaycush* from 18 sites across Lake Superior. We concurrently sampled *Mysis*, zooplankton, and the benthos to estimate invertebrate prey abundance, and fish for diet analysis in the spring, summer, and fall of 2005. *Mysis* was the most numerous prey item in the stomachs of kiyi (95%), deepwater sculpin (73%), bloater (67%), lake whitefish (60%), rainbow smelt (53%), but was not the dominant prey item for lake trout (15%), burbot (11%) and cisco (1%). Prey selectivities indicate that kiyi, deepwater sculpin, bloater, lake whitefish, and rainbow smelt are selecting for *Mysis* over more abundant zooplankton and *Diporeia*. Selectivities only changed marginally across seasons, and may be a result of stability in *Mysis* resources available to the fish community. *Keywords: Fish diets, Food chains, Trophic level.*

IVAN, L.N.¹, HÖÖK, T.O.¹, THOMAS, M.V.², and FIELDER, D.G.³, ¹Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN, 47907; ²Lake St. Clair Fisheries Research Station, Michigan DNR, Harrison Twp., MI, 48045; ³Alpena Fisheries Research Station, Michigan DNR, Alpena, MI, 49707. **Dynamics of the Saginaw Bay Fish Community (1970-2008).**

Saginaw Bay, a shallow bay of Lake Huron, has a long history of anthropogenic-induced stressors, including, sedimentation, eutrophication, and species invasions. Collectively, these stressors have undoubtedly impacted the Saginaw Bay fish community, which supports economically important fish species. We analyzed data collected by the Michigan DNR during fall trawl and gillnet surveys (1970-2008) to determine how the Saginaw Bay fish community has changed over time. Specifically, we used dynamic factor analysis (DFA) a statistical tool well suited for exploring temporal ordination of fish relative abundance and various explanatory variables. Our goals were 1) to elucidate which fish species trend together over time, 2) to

explore how key fish species abundance and biomass varied spatially within the bay, and 3) to evaluate what factors might be important determinants of fish community variation. We compared results from trawl and gill net surveys to determine if gear type influenced results. The results of this study will provide managers with information on fish community dynamics as well as what extrinsic variables drive fish community structure. *Keywords: Lake Huron, Fish populations, Ecosystems, Dynamic Factor Analysis.*

JAIN, N.¹, DEVANNA, K.M.², MAYER, C.M.², and SCHLOESSER, D.W.³, ¹Ottawa Hills High School, Toledo, OH, 43606; ²Department of Environmental Sciences and the Lake Erie Center, The University of Toledo, Toledo, OH, 43618; ³USGS Great Lakes Science Center, Ann Arbor, MI, 48105. **Mapping the Spatial Relationship of Burrowing Mayflies and Dreissenid Mussels in Western Lake Erie.**

Hexagenia (burrowing mayflies) recolonized western Lake Erie in the early 1990's providing an optimistic sign of improved water quality and an important food source for fish. However, *Hexagenia* densities may be affected by *Dreissena* (zebra and quagga mussels) distribution on soft sediment. Preliminary mesocosm experiments show that *Hexagenia* prefer *Dreissena*-covered sediments over bare sediment, but this finding has not been examined under field conditions. In this study we mapped *Hexagenia* and *Dreissena* distributions in western Lake Erie collected from multiple sites for four consecutive years (1999-2002). We found that the highest densities of *Hexagenia* (>600/m²) are found in areas with low *Dreissena* density (<100/m²). However, over 60% of the sites with *Dreissena* have at least 100 *Hexagenia*/m², suggesting that *Dreissena* do not inhibit *Hexagenia* presence. We also found that *Hexagenia* densities in western Lake Erie show high temporal and spatial variability. *Dreissena* clusters on soft sediments was not a preferred habitat at the spatial scale we examined in western Lake Erie, suggesting that different mechanisms affect *Hexagenia* habitat choice at small (mesocosm) vs. large (basin) spatial scales. *Keywords: Burrowing mayflies, Spatial distribution, Hexagenia, Dreissena, GIS, Lake Erie.*

JAMU, D., The WorldFish Center, Zomba, Malawi. **Resiliency as an Essential Aspect for Ecosystem Health.**

A resilient ecosystem has the ability to react to disturbances without shifting to a different state. Resiliency is important to ecosystem health because a regime shift may be irreversible and make the system biologically and economically unusable. We review the resilience concept and examine where it has been applied and where gaps exist in the management of Lake Malawi fisheries. Catches have stagnated and tilapia fisheries have been threatened or have collapsed. These fisheries are managed with the policy goal of maintaining maximum sustainable yields. To achieve this goal, fisheries managers regulate exploitation of fisheries resources in partnership with the resource users under different forms of co-management arrangements. Missing in the strategies, however, is a coherent approach that puts resilience of fisheries and fishing communities in context. We show how the resilient small-scale fisheries concept is relevant to the management of Lake Malawi fisheries and that its application would not require a significant

change to the existing fisheries management policy. *Keywords: Lake Malawi, Ecosystem health, Fish management.*

JANSSEN, J.¹ and SIDELEVA, V.², ¹WATER Inst., UW-Milwaukee, 600 East Greenfield Ave., Milwaukee, WI, 53204; ²Russian Academy of Sciences, St. Petersburg, Russia. **Are the Laurentian Great Lakes Too Young to be Healthy?**

We propose that defining ecosystem health for the Laurentian Great Lakes (LGL) will be an unusual challenge because their youth makes it difficult to compare the LGL to mature ecosystems. A major constraint for the biota of the main basins of the LGL is that the lakes' ages are only about 10,000 years. At that time most of the colonizing species were in rivers. In contrast, an old Great Lake such as Baikal has had sufficient time for within-basin evolution of some taxa. Perhaps the greatest contrast is with the oceans, which are far more ancient than any lake, and are tremendously diverse. The only truly ancient freshwater ecosystems are rivers, which are born when land rises from the sea. For example, by some estimates the New River (Appalachians) began carving its channel about 300 million years ago. The derivation of an indigenous biota derived from rivers may explain why the Laurentian Great Lakes' coastal areas, with quasiriverine currents and turbulence, harbor the greatest diversity. In contrast, diversity in the ocean and Lake Baikal is high even at great depth. With the constraints of restricted diversity and a biota scarcely adapted to meso-oceanic conditions it is unlikely that the Great Lakes have ever been "healthy" by standards useful for most ecosystems. *Keywords: Ecosystem health, Invasive species, Management.*

JENKINS, L.K., Michigan Tech Research Institute, 3600 Green Court, Suite 100, Ann Arbor, MI, 48105. **Remote Sensing-Based Object-Oriented Approach to Determine Frozen Lake Condition.**

The North Slope of Alaska encompasses 89,000 square miles. Lakes are a dominate feature on the North Slope, but due to the vast geographic area and remote location, ground surveys are not feasible and little data currently exists on these lakes. Building upon previous research, we have developed a remote sensing-based approach to distinguish between lakes on the North Slope that are completely frozen to the lakebed with lakes that have some liquid water. An object-orientated approach has been used to map freeze condition that utilizes the specific advantages of electro-optical and radar data to extract lake boundaries and areas of frozen water in a more accurate and efficient manner. Identification of freeze condition is useful for determining the feasibility of winter water withdrawal for oil and gas development activities and for assessing which lakes are capable of supporting diverse biota. Data outputs have also been used to enhance remote sensing based bathymetry algorithms. Our work on the North Slope could also be applicable to other shallow lakes in the Great Lakes basin and any other applicable cold regions of the world. *Keywords: Remote sensing, Ice, Satellite technology.*

JENSEN, E.S., DOSS, M., and MANNINEN, C., 2805 S. Industrial Hwy., Suite 100, Ann Arbor, MI, 48104. **Tracking Federal Legislative Activities to Advance Priorities for Great Lakes Restoration and Protection.**

To advance Great Lakes restoration and protection, the Great Lakes Commission (GLC) has developed a web-based tool to provide information on federal legislative activities related to the Great Lakes. The tool, hosted on the Great Lakes Information Network (GLIN), provides restoration advocates easy access to information on federal legislation and funding for restoration. Following Great Lakes Day 2007 and 2008, Great Lakes organizations are more united than ever before in presenting priority recommendations to Congress. The tool features the collective recommendations of the region's leading voices for congressional policy and funding, helping to promote a unified regional voice. The organization of the tool is based on the Great Lakes Regional Collaboration and the priority congressional requests of the GLC, Council of Great Lakes Governors, Great Lakes and St. Lawrence Cities Initiative, and Healing Our Waters®-Great Lakes Coalition, among others. Users can access information on the status of federal funding and authorizations for priority Great Lakes programs; Great Lakes members of Congress; congressional committees; and materials such as fact sheets and key correspondence. The tool facilitates participation in the legislative process, thus increasing support for advancing efforts to restore and protect the Great Lakes. *Keywords: Legislation, Policy making, Public education.*

JEZDIC, I. and DROUILLARD, K.G., 2990 Riverside Dr. W., Windsor, ON, N9B3P4.

Application of the Hazard Assessment Model with Spatially Explicit Water and Sediment Data to Predict Fish Consumption Advisories in the Detroit River.

A hazard assessment model was implemented to describe sport fish bioaccumulation of contaminants in the Detroit River to further assess causes of fish consumption advisories. Temporal and spatial variability in contamination complicates evaluation of chemical exposures and food web biomagnification of contaminants, such as polychlorinated biphenyls (PCBs). PCB concentrations in water and sediment (1998-2007) were compiled to evaluate spatial and temporal variability in the Lake Huron-Lake Erie corridor. These included mussel biomonitors (as surrogates of water) and sediment PCB concentrations, and sporadic direct water measurements from government and academic institutions. PCB concentrations in water and sediment were higher in the Detroit River and western Lake Erie compared to the Saint Clair River and Lake Saint Clair. They were higher on the American side than on the Canadian side of the Detroit River. While sediment PCB concentrations have remained stable over time, water PCB concentrations were highly variable and seemed to have increased at some sites in the river (Goyer's Marina, 0.13 ng/l in 1998 to 1.08 ng/l in 2006). The hazard assessment model was used to deduce areas in the Detroit River most likely to contribute to more restrictive fish consumption advisories. *Keywords: Biomagnification, Environmental contaminants, Fish consumption advisories.*

JOHENGEN, T.H.¹, DEMARCHI, C.², STOW, C.A.³, and HE, C.⁴, ¹Cooperative Institute for Limnology & Ecosystem Research, 4840 South State Rd, Ann Arbor, MI, 48108; ²Case Western

Reserve University, Dept of Geology, Cleveland, OH, 44106; ³NOAA Great Lakes Environmental Research Lab, 4840 South State Rd, Ann Arbor, MI, 48108; ⁴Western Michigan University, Dept of Geography, Kalamazoo, MI, 49008. **Evaluating Sediment and Nutrient Loading for the Saginaw River using an Intensive Sampling Program.**

Nutrient loading from the watershed is one of the primary stressors affecting coastal waters and the Great Lakes are not an exception to this trend. Therefore, as part of the Adaptive Integrated Framework project for managing the effects of multiple ecosystem stressors on the water quality and food webs of Saginaw Bay, Lake Huron, we developed an intensive monitoring effort of the Saginaw River and its main tributaries that was carried out in calendar year 2008. Discrete water samples were collected at two sites on the Saginaw River on 33 occasions and at the mouth of its four major tributaries on 8 occasions and analyzed for nutrients, solids and carbon concentrations. Continuous 15-min flow data was collected from an existing USGS gauging station at Saginaw, MI and corrected for unmonitored portions of the watershed. Results will describe multiple loading estimation approaches that were undertaken to examine potential biases and uncertainty resulting from sample density, flow stratification or seasonal stratification. Further, we compared our estimates with data collected by the Michigan Department of Environmental Quality and, using a Monte Carlo technique we evaluated the uncertainty in sediment and Phosphorous load estimates MDEQ computed for previous years. *Keywords: Nutrients, Pollution load, Sediment load.*

JOHNSON, J.E.¹ and SCHAEFFER, J.S.², ¹Michigan Department Natural Resources, Alpena Fishery Research Sta., 160 East Fletcher St., Alpena, MI, 49707; ²U.S.G.S. Great Lakes Science Center, 1451 Green Road,, Ann Arbor, MI, 48105. **Alewife Decline Causes Recruitment Limitation in Lake Huron Chinook Salmon.**

From 1976-2002 body condition and growth of Lake Huron Chinook salmon declined, suggesting increasingly limited prey supply. In 2003-04, alewives collapsed and growth of Chinook reached unprecedented low levels. Chinook recruitment declined sharply after 2003. Recruitment levels have remained low, despite a modest recovery in body condition and growth. Age-0 Chinook appeared in predator diets most often in years of low alewife abundance, suggesting a predation buffering effect from abundant alewives. Age-0 Chinooks and alewives were sampled together in similar habitats; principally near-shore, in depths < 25 m. Many of these habitats are now occupied by a nearly recovered walleye population. Diets of age-0 Chinooks were dominated by terrestrial and aquatic invertebrates and they seldom consumed alewives. Nor did alewives contribute to growth of yearling Chinooks, as evidenced by a lack of relationship between alewife abundance and yearling Chinook weights at a spawn-taking weir. Yet counts of age-1 Chinooks at the weir were positively correlated with alewife abundance in Lake Huron. Together, early life history and weir escapement data suggest that Lake Huron's Chinook salmon population has transitioned from prey to recruitment limitation. Evidently, an abundant alewife population buffers juvenile Chinook from predation. *Keywords: Alewife, Food chains, Salmon.*

JOHNSON, T.B.¹, HOYLE, J.A.¹, and ARTS, M.T.², ¹Ontario Ministry of Natural Resources, Glenora Fisheries Station, Picton, ON, K0K 2T0; ²Environment Canada, National Water Research Institute, Burlington, ON, L7R 4A6. **Physiologic Health of Lake Whitefish in Lake Ontario - Interstock Differences.**

Lake whitefish *Coregonus clupeaformis* are an economic and ecologically important fish throughout the Great Lakes basin. During the past decade, lake whitefish growth and condition has declined for many stocks. We used a variety of morphometric and physiologic indicators to compare the relative health of the two dominant stocks in Lake Ontario. Fish spawning in the lower Bay of Quinte are younger and smaller than those spawning in the lake proper. Even after correcting for differences in body size, Bay fish were of poorer condition (relative weight) and had lower total lipids and essential fatty acids. Energy density of Bay fish was marginally higher owing to a significantly higher nitrogen content. While it is assumed both stocks cohabitate during the non-spawning season, stable isotope signatures revealed Bay fish were more depleted in $\delta^{13}\text{C}$ and slightly enriched in $\delta^{15}\text{N}$ suggesting different trophic experiences. Following the near collapse of lake whitefish stocks in eastern Lake Ontario in the mid 1990s, the Bay stock is now growing slower and maturing at a later age impacting recovery potential. Our analyses suggest Bay fish have been more heavily impacted by ecological change than the Lake stock and differences in nutritional history has resulted in their poorer performance. *Keywords: Fish management, Fish health, Stable isotopes, Whitefish, Bioindicators.*

JOHNSTON, J.W.¹, ARGYILAN, E.P.², LEPPER, K.³, THOMPSON, T.A.⁴, BAEDKE, S.J.⁵, and WILCOX, D.A.⁶, ¹Department of Geography and Environmental Studies, Wilfrid Laurier University, 75 University Avenue West, Waterloo, ON, N2L 3C5; ²Dept. of Geosciences, Indiana University Northwest, 3400 W. Broadway, 236 Marram Hall, Gary, IN, 46408; ³Optical Dating and Dosimetry Lab, North Dakota State University, Department of Geosciences, 218 Stevens Hall, Fargo, ND, 58105; ⁴Indiana Geological Survey, Indiana University, 611 North Walnut Grove, Bloomington, IN, 47405-2208; ⁵Geology and Environmental Science, James Madison University, 395 S. High Street; MSC 6903, Harrisonburg, VA, 22807; ⁶Environmental Science and Biology, SUNY-Brockport, 350 New Campus Drive, Brockport, NY, 14420. **Late Holocene Lake-Level Paleo-Hydrograph for Lake Superior Constructed from Hundreds of Ancient Shorelines.**

Lake Superior is among the largest lakes in the world and plays an important role in the Laurentian Great Lakes because it is situated at the head of the largest fresh, surface-water system on earth. The most complete and accurate record of natural lake-level rhythms, extending beyond instrumental records to five millennia, was extracted from well-preserved, ancient shorelines that rim the lake. Elevations were measured by coring and surveying about 300 beach ridges while ages were modeled from about 70 OSL age determinations obtained from five different study sites. An elevation trend change across each strandplain is associated with an outlet change for Lake Superior from Sarnia/Port Huron to Sault Ste. Marie. Correlation between study sites and age model results suggest Lake Superior completed its separation from Lake Michigan and Huron about 1,200 years ago. GIA estimates from geologic and water-level gauge data indicate the separation process may have initiated and occurred briefly about 1,000 and 2,000 years previous, during millennial low-water stages after the Algoma and Nipissing high

water-level phases, respectively. Unraveling correct long-term rates of GIA with many superimposed natural lake-level fluctuations provides the historical context needed to effectively manage the future of our water resources. *Keywords: Lake Superior, Water level, Coasts.*

JONAS, J.L.¹, CLARAMUNT, R.M.¹, MARSDEN, J.E.², FITZSIMONS, J.D.³, and ELLROTT, B.J.⁴, ¹Michigan Department of Natural Resources, 96 Grant Street, Charlevoix, MI, 49720, USA; ²School of Natural Resources, University of Vermont, Burlington, VT, 5405, USA; ³Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6, Canada; ⁴Surface Water Resources, Inc., 2031 Howe Avenue, Sacramento, CA, 95825, USA. **Simulating Survival of Lake Trout Eggs under Various Climate and Predation Scenarios.**

A simulation model was developed to evaluate lake trout survival from egg deposition to fry emergence and tested responses to a variety of scenarios incorporating (1) fall cooling patterns, (2) the timing and duration of egg deposition, and (3) varied interstitial egg predator species, densities, and sizes. The survival of lake trout eggs was strongly influenced by fall cooling patterns which affected the success of lake trout egg predators. The most rapid cooling scenarios increased the potential for egg survival. Delayed peak spawn dates which occurred over compressed time periods were best for lake trout egg survival. The predation potential of crayfish, sculpin and round gobies was evaluated for a range of density and size scenarios. Round gobies of similar density ($10 \pm 14 \cdot m^{-2}$) and size (55 ± 7 mm total length) were least effective as predators, when compared to sculpin ($10 \pm 14 \cdot m^{-2}$; 55 ± 7 mm carapace length) or crayfish ($10 \pm 14 \cdot m^{-2}$; 30 ± 5 mm carapace length). Attraction to freshly deposited eggs and overwinter departure from spawning reefs had minimal effect in increasing predation losses to round goby. The simulation model can be used to evaluate the probability of survival to the fry stage given unique combinations of predators and fall cooling scenarios when site- or region-specific information is provided. *Keywords: Predation, Lake trout, Fall cooling pattern.*

JONES, A., Anishinabek Womens Water Commisison, Union of Ontario Indians, Nipissing First Nation, ON. **Anishinabek Traditional Knowledge and the Implementation of the Great Lakes – St. Lawrence River Basin Sustainable Water Resources Agreement.**

The Anishinabek people are taught to think beyond the current generation when considering matters of great importance – to continually ask ourselves what we are leaving for a future seventh generation. The Anishinabek accepted a sacred covenant to protect and preserve the lands and waters of our Mother Earth and that women have first responsibility to care for and carry the Water of Life. The Anishinabek Women's Water Commission were appointed in 2007 by the Anishinabek Nation Grand Council Chief to play a leadership role in raising the awareness of Great Lakes water and impacts to its quality and quantity and to also share their traditional knowledge and teachings about water. Through teachings and ceremony the Commission will work with the Province of Ontario to implement the Great Lakes St. Lawrence River Basin Sustainable Water Resources Agreement. Traditional knowledge and values will become part of policies and programs. Our belief that water is living and spoken for by women will now be reflected in Ontario's water management regime. *Keywords: Aboriginal, First Nations, Great Lakes basin.*

JONES, E.L.¹, LEON, L.F.¹, ZHAO, Y.², SMITH, R.E.H.¹, and CRAIG, J.R.¹, ¹University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1; ²O.M.N.R., L. Erie Fisheries Station, 320 Milo Rd., Wheatly, ON, N0P 2P0. **Three-Dimensional Modelling of Walleye Nursery Habitat in West Basin Lake Erie.**

The 3-dimensional hydrodynamic model, ELCOM, was coupled with the ecological model, CAEDYM, to describe physical and biological processes within Lake Erie. Previous work with this model has shown success in lakewide hydrodynamic and oxygen predictions as well as for water quality parameters such as phosphorus, nitrogen, and phytoplankton. One application for this model is as a tool for predicting walleye recruitment in Lake Erie. The west basin provides essential nursery areas for walleye larval development. It is believed that the southern nearshore area and the Maumee River plume in the west basin with its warm temperatures, high levels of turbidity (for cover), and high zooplankton biomass should provide a favourable nursery area. Zooplankton food supply appears to be generally good, but there is a high degree of spatial variability. Three-dimensional modelling of zooplankton offers an estimate of spatial distribution of zooplankton and turbidity during the larval critical period. Model predictions will be compared to available measurements, and the variability of nursery habitat quality discussed with respect to walleye recruitment potential. *Keywords: Ecosystem modeling, Lake Erie, Fisheries.*

JOSEPH, S.T., 4840 South State Street, NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 48108. **Great Lakes and Human Health: Communicating Water Quality.**

Communicating human health risks to educate and raise awareness while minimizing public misinformation and hysteria requires a multi-faceted approach. Methods and techniques for engaging the local environmental managers/ decision makers, the public and media on water quality issues will be presented. Using case studies from stakeholder training workshops and public meetings, Michigan Sea Grant and the NOAA Center of Excellence for Great Lakes and Human Health will feature scientific communication strategies and techniques that have worked and have not worked, successes and failures to engage stakeholders and scientists, and why public outreach and communication are vital components of scientific research. *Keywords: Outreach, Water quality.*

JUDE, D.J.¹, REDISKE, R.R.², O'KEEFE, J.², HENSLER, S.R.¹, and GIESY, J.P.³, ¹University of Michigan, School of Natural Resources, 440 Church Street, Ann Arbor, MI, 48109; ²Annis Water Institute, Grand Valley State University, 740 West Shoreline Dr., Muskegon, MI, 49441; ³Department of Veterinarian and Biomedical Science and Toxicological Centre, Univ. of Saskatchewan, Saskatoon, SK, S7N 2X8. **PCBs Concentrations in Saginaw River Walleyes and Their Prey: 1990 vs. 2007.**

PCBs were measured in biota collected during 2007 and 1990 from Saginaw River and Saginaw Bay. Many different gear were used to collect fishes. We compared PCBs in walleyes and their prey from 1990 with those from 2007 to determine if dredging/environmental processes in the Saginaw River resulted in decreased PCBs. There was a direct linear relationship between fish length and PCBs in walleyes 355 - 600 mm, but fish > 680 mm had lesser concentrations than 600-mm fish. When fish 355 - 600 mm from 1990 were compared with those from 2007, there was a decrease of 1,315 ng PCBs/g wet wt. (COVARIANCE). PCBs in small gizzard shad collected in 2007 (190 ng PCBs) were significantly less than comparable fish in 1990 (516 ng PCBs). Saginaw River round gobies exhibited a linear relationship between length and PCBs and had the most PCBs (200 - 350 ng PCBs) among prey fish. PCBs in other prey fish from the Saginaw River and Bay ranged from 45 to 88 ng PCBs; zooplankton from 1990 contained 8.0 ng PCBs. PCBs from round gobies from the Saginaw River were 3X greater than those found in Saginaw Bay, reflecting greater levels of PCBs in the river. PCBs congeners were highest in 600-mm walleyes. Dredging and environmental burial of PCBs in the sediments resulted in a decrease in concentrations in walleyes and their prey. *Keywords: Bioaccumulation, Round goby, Food chains.*

KANE, D.D.¹, CONROY, J.D.², RICHARDS, R.P.³, BAKER, D.B.³, and CULVER, D.A.⁴,
¹Natural Sciences and Mathematics Division, Defiance College, Defiance, OH, 43512; ²Aquatic Ecology Laboratory, Department of Evolution, Ecology, and Organismal Biology, The Ohio State University, Columbus, OH, 43212; ³National Center for Water Quality Research, Heidelberg College, Tiffin, OH, 44883; ⁴Limnology Laboratory, Department of Evolution, Ecology, and Organismal Biology, The Ohio State University, Columbus, OH, 43212. **Western Lake Erie Nuisance Algae: Correlations between Nutrient Load and Total Phytoplankton and Cyanobacterial Biomass.**

Both abiotic and biotic explanations have been proposed to explain recurrent nuisance algal blooms in the western basin (WB) of Lake Erie. We used two long-term datasets to test whether WB total phytoplankton biomass (Total PP) and cyanobacterial biomass (CB) correlated with soluble reactive phosphorus (SRP) loading and nitrate (NO₃) loading from agriculturally-dominated tributaries (Maumee and Sandusky rivers). We constructed linear regression models to determine if Total PP and CB, individually, correlated with either SRP-load or NO₃-load. Total PP and CB seasonal (May–October) average (arithmetic mean) wet-weight biomasses each significantly increased with increased water-year total SRP load from the Maumee River and the sum of SRP load from the Maumee and Sandusky rivers, but not for the Sandusky River. However, when using seasonal median Total PP and CB as response variables to remove the influence of bloom events and the Beale Ratio Estimator to account for missing SRP data, only the relationship between median CB and Beale-ratio estimated SRP load were significant. No regressions of Total PP or CB vs. NO₃-load were significant. In conclusion, recent increased tributary SRP loads likely contribute most to increased WB cyanobacterial biomass and more frequent occurrence of harmful algal blooms. *Keywords: Nutrients, Lake Erie, Harmful algal blooms.*

KAPO, K. and BURTON, G.A., Dept. of Earth and Environmental Sciences, Wright State University, Dayton, OH, 45435. **Delineation of Stressor-Response Associations using Regional Spatial Analysis of Archival Ohio Watershed Data.**

The determination of stressor-response relationships and the prioritization of efforts regarding multiple stressor scenarios is a challenge in environmental management and decision-making. The application of data analysis techniques to multiple spatially-integrated archival data sources can optimize existing data resources, provide useful hypotheses for potential causes of ecological impairment, and guide future data collection and research efforts. In this study, spatial analysis of archival sampled and modeled biological, physical, and chemistry data for regional Ohio watersheds via Bayesian analysis and logistic regression was conducted to delineate stressor-response associations and prioritize environmental stressors. Stressors identified in the analysis varied by predominant land use and by biological endpoint (fish community index, species abundance, species loss). Impairment prediction maps and results produced by the spatial analysis provide screening-level hypotheses based on geographic associations between stressors and ecological impact. This type of analysis approach, with study-dependent refinements and modifications applied as needed, is a potential tool for developing quantitative evidence utilized within a larger framework for eco-epidemiological assessment. *Keywords: Environmental contaminants, Environmental health, Spatial analysis.*

KARATAYEV, A.Y.¹, BURLAKOVA, L.E.¹, MASTITSKY, S.E.¹, PADILLA, D.K.², and MILLS, E.L.³, ¹Great Lakes Center, Buffalo State College, 1300 Elmwood Ave., Buffalo, NY, 14222; ²Department of Ecology and Evolution, Stony Brook University, 650 Life Sciences Building, Stony Brook, NY, 11794-5245; ³Department of Natural Resources, Cornell Biological Field Station, 900 Shackelton Point Road, Bridgeport, NY, 13030. **Invasion Paradox: Why do Less Invasive *Dreissena rostriformis bugensis* Outcompete *D. polymorpha*?**

Although *Dreissena polymorpha* and its congener *Dreissena rostriformis bugensis* have similar life histories, they have very different invasion histories and patterns of spread among and within waterbodies. *Dreissena polymorpha*'s colonization of Europe began over 200 years ago and their spread was exponential for about 70 years, and then grounded to a halt. In the second half of the 20th century this species once again spread rapidly across Europe, invaded and spread across North America. In contrast, *D. r. bugensis* did not begin to spread beyond its native range until the 1940s. However within a few decades, their rate of spread increased dramatically and during the last decade has been twice as high as that of *D. polymorpha*. Although both species have coexisted in their native range for thousands of years, in invaded waterbodies, it now appears that in less than a decade of coexistence, *D. r. bugensis* often out competes *D. polymorpha*. However, there are cases where it takes *D. r. bugensis* much longer to out compete *D. polymorpha* and areas where *D. polymorpha* continues to dominate. We will discuss the vectors of spread, environmental conditions, and population dynamics of these two species in areas where they are invasive. *Keywords: Invasive species, Competition, Zebra mussels, Spread, Distribution patterns.*

KARSIOTIS, S.R.², BROWN, J.E.¹, LOHNER, R.N.¹, and STEPIEN, C.A.¹, ¹Lake Erie Center, University of Toledo, Toledo, OH, 43618, USA; ²Clay High School, 5665 Seaman Rd., Oregon, OH, 43616. **Salinity Tolerance of the Exotic Round Goby: Experimental Implications for Seawater Ballast Exchange.**

The Eurasian round goby *Neogobius melanostomus* invaded the North American Great Lakes in 1990 via ballast water introduction from the Black Sea area (where they live in 0-15 ppt salinities), and since spread throughout watersheds and adjacent riverine systems. Legislation now requires oceanic ballast water exchange of vessels entering the Great Lakes, whose salinity effects are unknown on gobies. We tested 230 juvenile and adult round gobies in salinity tolerance experiments with 20 gobies per treatment at 0 (control), 5, 10, 15, 20, 25, 30, 35, and 40 ppt - with 32 ppt being oceanic conditions - in immediate immersion versus longer-term acclimation experiments (increasing 5 ppt every 3 days). Immersion experiments showed 95-100% survivorship at 0-10 ppt, 70-80% for 15-20 ppt, 20% at 25 ppt, and 0% in 30-40 ppt. Acclimation experimental results were 95-100% survival in salinities of 0-20 ppt, 80% in 25 ppt, and 0% at 30 ppt. In long-term experiments, Lake Erie round gobies lived at salinities to 20 ppt for 3+ months. Thus, round gobies readily tolerate and acclimate to estuarine conditions, and are unlikely to be killed by incomplete oceanic ballast water exchange. We predict that the round goby will flourish in estuaries along North American coasts, where they will consume their native mytilid mussel prey. *Keywords: Ballast, Exotic species, Round goby.*

KASHIAN, D.R.¹, KRAUSE, A.E.², SANO, L.L.³, DROUILLARD, K.G.⁴, and HAFFNER, G.D.⁴, ¹Wayne State University, Department of Biological Sciences, Detroit, MI, 48202; ²University of Toledo, Department of Environmental Sciences, Toledo, OH; ³Marine Conservation Biology Institute, Glen Ellen, CA; ⁴University of Windsor, Great Lakes Institute for Environmental Research, Windsor, ON, N9B 3P4. **Addressing Fish Consumption Advisory Issues via an Integrated Assessment Approach: A Case Study of the Detroit River.**

The Detroit River is an international connecting channel linking the upper and lower Great Lakes. The river remains under several fish consumption advisories for mercury, PCBs and dioxin, which are beneficial use impairments that impact human health and affect economic revenue for both the U.S. and Canada. Despite the importance of these advisories, little progress has been made in developing effective management strategies and coordinating monitoring, research and policy efforts between the two nations. Many uncertainties remain regarding the drivers of these advisories, with key uncertainties including the relative contribution of sediment hot spots, the role of point vs. non-point contaminant sources, and the appropriateness of tissue trigger-levels in identifying threshold action levels for the advisories. Because of these complexities, solutions for remedying consumption advisories require novel approaches directed at decreasing body burden levels in fish and reducing human health risks. We are addressing these issues using an Integrated Assessment approach. We have coordinated over 69 organizations involved with the release of contaminants, with developing consumption advisories, or that are affected by or concerned about fish contamination in the Detroit River system to identify and address top management priorities. *Keywords: Detroit River, Human health, Environmental contaminants.*

KASHIAN, D.R.¹, KRAUSE, A.E.², SANO, L.L.³, DROUILLARD, K.G.⁴, and HAFFNER, G.D.⁴, ¹Wayne State University, Department of Biological Sciences, Detroit, MI; ²University of Toledo, Department of Environmental Sciences, Toledo, OH; ³Marine Conservation Biology Institute, Glen Ellen, CA; ⁴University of Windsor, Great Lakes Institute for Environmental Research, Windsor, ON, N9B 3P4. **A New Approach for Addressing Fish Consumption Advisories in the Great Lakes.**

Fishing the Great Lakes is an enjoyable recreational activity and caught fish can be a healthy part of your diet. Fish are a great source of protein, vitamins, and minerals and may reduce the risk of heart disease, diabetes and other illnesses. However, some fish in the Great Lakes have become polluted from chemicals such as mercury, dioxin, and PCBs that end up in the lakes from industrial uses and storm-water runoff. These fish can be harmful to your health if eaten too often. Eating polluted fish will not make you sick right away but these chemicals can build up in your body and cause illnesses later in life. These chemicals are especially dangerous in pregnant women and children. To protect people from getting sick, many states issue advisories to warn people which fish can cause illness. Advisories provide guidelines on the amount and type of fish that can safely be eaten by children, pregnant women and other adults. These advisories are often difficult to interpret and vary among regions in how fish are tested for chemicals and the advice given. We are using a new method combining science and communication to reduce confusion around the advisories, and identify ways to reduce pollution in fish. *Keywords: Pollution load, Fish toxins, Policy making.*

KELLOGG, W.A., Cleveland State University, 2121 Euclid Avenue, Cleveland, OH, 44115. **A Collaborative Governance Network for Land Use Decision Making in Lake Erie's Tributary Rivers: Ohio's Balanced Growth Program.**

This paper describes the collaborative governance network (CGN) formed to develop and implement the Ohio Lake Erie Commissions' Balanced Growth Program (BGP). Collaborative governance for environmental management has become an important conceptual framework for understanding public processes in the last several decades. A CGN extends and shares responsibility with stakeholders outside the formal government to co-produce and achieve public policy goals. The impetus for collaboration in the BGP arose from a changing policy context and the need for expertise and resources outside the commission agencies' traditional knowledge domain. The network of collaborators engaged in the Balanced Growth program included a broad range of state agencies, regional and local governments, universities, stakeholders, and citizens. The CGN is described in terms of the inter-organizational relationships that developed, the organizational structure of the BGP, the policy objectives adopted, and the implementation mechanisms that were designed. Results are described in terms of benefits to program design, program implementation, and a set of capacity-related outcomes and in terms of the challenges remaining to this CGN to achieve its goals. *Keywords: Decision making, Lake Erie, Watersheds.*

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

KELLY, J.R.¹, YURISTA, P.M.¹, STOCKWELL, J.D.², ISAAC, E.J.³, MILLER, S.E.¹, SCHAROLD, J.V.¹, CORRY, T.D.¹, JOHNSON, T.B.⁵, JOHANNSSON, O.E.⁴, MUNAWAR, M.⁴, and RICHARDSON, V.⁶, ¹Mid-Continent Ecology Division, U.S. Environmental Protection Agency, Duluth, MN, 55804; ²Gulf of Maine Research Institute, Portland, ME, 4101; ³Water Resource Science, University of Minnesota Duluth, Duluth, MN, 55804; ⁴Fisheries and Oceans Canada, Burlington, ON; ⁵Ontario Ministry of Natural Resources, Peterborough, ON; ⁶Environment Canada, Burlington, ON. **Big Numbers for the Big Lake: A Lower Food Web Assessment of Lake Superior (2004-2006).**

Our collaborative binational studies focused on lower trophic levels (plankton, mysids, benthos) of Lake Superior based on comprehensive sampling (2004 to 2006). Information is integrated for a lakewide summary, but also to display patterns among lower food web components by depth. There were > 40 trillion individuals of the principal benthic prey, *Diporeia*, which had an aggregate biomass of ~66 thousand metric tons wet weight. For reference, this biomass is larger than that of the humans living within the Lake Superior basin. As big as those numbers are, the benthos was the least contributor among measured lower food web components. An estimated *Diporeia*-to-mysids-to-zooplankton (DMZ) biomass ratio was ~1 : 5 : 19 for the lakewide summary. The 20-80 m depth zone was replete with *Diporeia* and low in mysids — a DMZ ratio was ~1 : 0.6 : 4. In contrast, a DMZ ratio was ~1 : 9 : 38 in midwaters (80-200 m) which represent a majority (~53%) of the lake area. Further offshore (>200 m) zooplankton and mysids dominate the biomass; the DMZ ratio was ~1 : 69 : 178. These studies are strong foundation for: a) provision of quantitative estimates and related uncertainties for the lower food web, b) comparison to conditions comprehensively assessed in the 1970s, and c) evaluation of large lake bioassessment strategies. *Keywords: Assessments, Benthos, Mysids, Zooplankton.*

KELLY, M.D. and CAMPBELL, L.M., Department of Biology, Queen's University, Kingston, ON, K7L 3N6. **Historical Comparisons Concerning the Acidification of Ontario Lakes and Impacts on the Bioavailability of Mercury.**

The accumulation of mercury in biotic species continues to be observed in Canadian lakes. Mercury is transported from anthropogenic sources and enters aquatic systems by wet and dry deposition, in addition to naturally occurring deposits. Enriching in the sediments of lakes and under anaerobic conditions, mercury is transformed into methylmercury becoming increasingly available to biota. The regulation of biological uptake of mercury is affected by a number of geochemical factors, including redox states, lake water acidity, and reactions with inorganic ions or sulphides, which vary seasonally. Lakes in the region of Dorset, Ontario with diverse histories of acidification, from acidified to unimpacted, will be examined using paleolimnological techniques. Analyses of modern and archived fish tissue samples will help unveil pathways of mercury cycling in these lakes through the interactions of acidification, methylation of mercury, and the biotic uptake of mercury. *Keywords: Paleolimnology, Mercury, Fish toxins.*

KENDALL, A.D.¹, HYNDMAN, D.¹, PIJANOWSKI, B.C.², and RAY, D.K.², ¹206 Natural Sciences Building, Michigan State University, East Lansing, MI, 48824; ²Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN, 47906. **Simulating Impacts of Climate and Land Use Change on Regional Hydrology at Fine Resolution with the Integrated Landscape Hydrology Model (ILHM).**

Climate and land use change will alter hydrology and impact water resources globally, but the effects of these changes are experienced locally. In the U.S., most water resource and land use planning takes place at intermediate scales. Unfortunately, existing hydrologic simulation tools are either semi-empirical models well suited for regional- to global-scale modeling, or fully-coupled process-based models useful only for very small watersheds. This mismatch of scale and purpose between predictive modeling and resource management limits our ability to quantify, respond to, and mitigate potential changes. The Integrated Landscape Hydrology Model (ILHM) is a novel water- and energy-balance physics-based model capable of simulating regional scale (>10,000 km²) hydrology at fine resolution (~100 m). ILHM simulates nearly the entire terrestrial hydrologic cycle using readily available GIS, remote sensing, and gauged inputs. Here we present a series of 120 year simulations of the Muskegon River Watershed in Michigan, U.S.A. that backcast to 1980 and forecast to 2100. We compare the impacts of simulated climate change alone to the combined impacts of simulated climate and land use changes. Under all scenarios, soil moisture, evaporation, transpiration, ground water recharge, and stream flows are significantly altered. *Keywords: Hydrologic cycle, Climate change, Land use change.*

KENNEDY, G.W., MANNY, B.A., and CRAIG, J.M., US Geological Survey, Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105, USA. **Egg Deposition, Distribution and Spawning Habitat Preference of Fish in the Detroit River, North America.**

Historical records indicate that the Detroit River had a thriving commercial fishery, and was considered a prolific spawning ground for many fish species. Over-fishing and loss of spawning habitat due to channelization and industrialization contributed to the demise of this fishery more than 90 years ago. Recent recovery of lake whitefish, walleye, and other fish populations in nearby Lake Erie, however, led us to postulate that spawning and fry production in the Detroit River may also be increasing as well. We sampled for eggs using passive egg mats at up to 31 sites throughout the Detroit River, during the fall and spring, from 2006 through 2008, to identify and map egg deposition, distribution and spawning habitat preference. Several species of eggs were collected during all spring sampling periods, including Walleye, several species of suckers, and white bass white perch eggs. Only lake whitefish eggs were collected during fall sampling periods. Distribution and egg density varied widely both from site to site and from year to year. Walleye eggs were the most prevalent collected, with a density of up to 15,000 / m² observed at the sturgeon spawning reef restoration site near Belle Isle. These results provide good baseline information for management activities and habitat restoration projects in the Detroit River. *Keywords: Detroit River, Fish, Spatial distribution.*

KIGER, S.¹, HERR, H.², BOHRER, J.², BRIGHAM, S.², COBLENTZ, S.², KICK, T.², LIVENGOOD, A.², LOWE, A.², NUSSBAUM, M.², and VODIKA, T.², ¹The Ohio State University, Wooster, OH; ²Kingsway Christian School, Orrville, OH. **Kingsway Christian School's Drinking Water Project.**

Non-contaminated drinking water is something many Americans take for granted. In rural communities however, drinking water may often come from a private source, which isn't regulated, tested, or treated like the public water system. By adding a unit on drinking water quality to a high school environmental science curriculum, we can educate students on drinking water quality while also exploring scientific methods. This project allows students to study contaminants and their sources in drinking water, explore ways to test and remove these contaminants from the water, and find ways to prevent contaminants from getting in the water to begin with. The main objective of this project is to have students compare public and private drinking water quality in a classroom setting. In this project students measure levels of nitrate and presence of coliform in drinking water samples collected from school families. While providing a service to the school, this project also engages students in a long-term (4-5 month) project where they form hypotheses, develop collection and testing methodology, provide graphical results, and present their findings visually, orally and in writing. This project teaches research methods, exposes students to real-life science applications, and also educates the public on drinking water contamination and testing. *Keywords: Water quality, Education, Environmental health.*

KILBERT, K.K., University of Toledo College of Law, 2801 W. Bancroft Street, Toledo, OH, 43606. **The Great Lakes - St. Lawrence River Basin Water Resources Compact and its Interface with Existing Anti-Diversion Law.**

The Great Lakes – St. Lawrence River Basin Water Resources Compact is designed, in large measure, to protect Great Lakes waters from being diverted beyond the Great Lakes basin. One of the factors which drove the creation and ratification of the Compact was the perception that existing laws, particularly the Water Resources Development Act of 1986 (WRDA), were inadequate to protect against out-of-basin diversions. But the Compact, as ratified by the Great Lakes states and the U.S. Congress in 2008, does not expressly repeal WRDA or its provision which prohibits out-of-basin diversions absent approval by the governors of all eight Great Lakes states. So what role, if any, does WRDA continue to play in governing out-of-basin diversions of Great Lakes waters today, in light of the new Compact? This presentation explores the issue and concludes that the terms of the Compact governing out-of-basin diversions of Great Lakes waters, including its exceptions and standards, supercede the simple approve-or-veto provision of WRDA. *Keywords: Legislation, Great Lakes basin, Water management.*

KIM, R., WEEKS, C., MILLARD, E., SHAVALIER, M., and FAISAL, M., College of Veterinary Medicine, Michigan State University, East Lansing, MI, 48824. **Comparative Susceptibility of Representative Great Lakes Fish Species to the Emerging Strain of Viral Hemorrhagic Septicemia Virus.**

Isolation of Viral Hemorrhagic Septicemia Virus (VHSV) in fish kills and field surveys in the Great Lakes has yielded important data about the virus phylogeny and range. Since most of the fish used in virus isolation were either dead for unspecified time or apparently healthy, little could be drawn about the disease course or the tissue alterations that the virus caused. Therefore, the present study was designed for a number of purposes. First, to fulfill Koch's postulates and thereby ascertain that the VHSV isolated during mortality episodes is indeed the cause of fish kills. Second, to compare the susceptibility of important Great Lakes fish species to the novel VHSV strain (genotype IVb). Third, to determine the median lethal dose of infection causing 50% mortality. Fourth, to elucidate the course of disease. Last, to describe the tissue alterations caused by the virus in infected fish tissues. Although mortalities were observed in all species used, the most susceptible species were the muskellunge, followed by largemouth bass. The least susceptible were all salmonid species. Depending on the dose of exposure, VHSV infection can run peracute, acute, subacute, or subclinical course of infection. Survivors can harbor the virus for up to nine months. Infected fish suffered from lymphoid depletion of spleen and kidneys. *Keywords: Ecosystem health, Risks, Trophic level.*

KISH, J.L.¹, OSTER, R.J.¹, WERNE, J.P.², and HICKS, R.E.¹, ¹University of Minnesota Duluth James I. Swenson Science Building 207, 1035 Kirby Drive, Duluth, MN, 55805; ²University of Minnesota Duluth - Large Lakes Observatory, Research Laboratory Building 109 2205 E. 5th Street, Duluth, MN, 55805. **Archaeal Diversity in the Pelagic Zone of Lake Superior.**

Ecological information about planktonic microbial communities can aid our understanding of in-lake processes and temperature proxies used to evaluate past lake conditions. Archaeal abundance and community structure were examined in Lake Superior during 2007 and 2008. T-RFLP fingerprints of archaeal communities from various depths were compared during both stratified and mixed lake conditions. Two discrete clusters of planktonic archaeal assemblages were often present under stratified conditions. One cluster was associated with the thermocline and chlorophyll maximum, and the other with archaeal assemblages found throughout the deep hypolimnion. Sequences were obtained from archaeal and crenarchaeal 16S rDNA clones from both these zones. Planktonic archaeal communities were very similar when the lake was mixed. The greatest difference in T-RFLP fingerprints was seen when sediment and planktonic archaeal communities were compared. Similar patterns appeared when the abundance of the archaeal 16S rDNA gene was quantified using qPCR. After stratification, archaeal 16S rDNA was more abundant below the chlorophyll maximum in the mid-hypolimnion and in the deep hypolimnion near the sediment but much less abundant in the epilimnion. Planktonic Archaea may form discrete communities in the water column and are present most of the year. *Keywords: Microbiological studies, Picoplankton, Archaea.*

KLUMP, J.V. and WAPLES, J.T., Great Lakes WATER Institute, University of Wisconsin-Milwaukee, Milwaukee, WI, 53204. **Climate Variability and Alterations in the Hydrodynamics, Particle Transport, Resuspension, Carbon Cycling, and Hypoxia in Green Bay.**

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

Over the last several decades the predominant summer wind field has changed in Green Bay in response to a climatological, southerly shift in the typical storm track through the Great Lakes region. This wind shift appears to alter the hydrodynamics of the bay, resulting in a reduction in water mass exchange with Lake Michigan, more efficient retention of particles within the bay, and a reduction in sediment resuspension during late summer. Time series measurements of currents, turbidity, dissolved oxygen, and the Be-7 activity of particulates in bottom sediments, sediment traps, and suspended particulates have been made from May-October over a 3 year period (2004-06) and have been compared with identical measurements made in 1990. Meteorological data reported from NDBC buoys have been analyzed for the period of 1985 to 2006. The consequences of enhanced particle retention and altered thermal structure in response to shifted winds appear to include a significant increase in the organic carbon content of suspended matter, an accelerated flux of organic carbon to the sediments, an increase in the incidence and duration of hypoxia, and enhanced fluxes of methane during late summer. *Keywords: Biogeochemistry, Climate change, Hydrodynamics.*

KLUMP, J.V., Great Lakes WATER Institute, University of Wisconsin-Milwaukee, Milwaukee, WI, 53204. **The Great Lakes WATER Institute of the University of Wisconsin-Milwaukee.**

The University of Wisconsin-Milwaukee Great Lakes WATER (Wisconsin Aquatic Technology and Environmental Research) Institute has its origins in the establishment of the Center for Great Lakes Studies in 1966. The institution was reorganized in 1998 as the WATER Institute. Located on Milwaukee's inner harbor, the Institute has operated the research vessel Neeskey year round on the lakes since 1969. Today the Institute serves as home for University research scientists and faculty, the Great Lakes Aquaculture Center, the Great Lakes office of the NOAA National Undersea Research Center, the Lake Michigan Fisheries Management Unit of the Wisconsin DNR, an Advisory Services office of the Wisconsin Sea Grant program, the USDA Agriculture Research Services Great Lakes aquaculture program, and the home port for the US EPA research vessel Lake Guardian. In 2008, the WATER Institute and the UW-Milwaukee received authorization, pending legislative approval expected in 2009, to form the nation's first graduate School of Freshwater Sciences, offering doctoral and masters degrees in freshwater science and engineering. Our mission is to advance fundamental and strategic science that will inform policy, improve management, and promote the health of the Great Lakes and freshwater systems worldwide. *Keywords: Lake Michigan, Education, Ecosystems.*

KOBUS, D.L., 600 Forbes Avenue, 339C Fisher Hall, Pittsburgh, PA, 15282, USA.

Professional Credentials Increase Marketability and Show Commitment to High Standards in Emerging Environmental Job Markets.

The Institute of Professional Environmental Practice is an independent, not-for-profit certifying organization for the QEP and EPI credentials and is a fully accredited member of the Council of Engineering and Scientific Specialty Boards. IPEP's international membership is employed in a broad spectrum of fields spanning industry, agency, consulting and academia. Underscoring the importance of maintaining high practice standards in the emerging 'green' economy as well as being able to continue to work from a strong base of knowledge, IPEP

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

certifies its members through multi-media, multidisciplinary exams in the areas of air, management & policy, waste, and water. These exams test both depth and breadth of knowledge, and the organization requires its approximately 1,000 members to also commit to professional development requirements and a strict Code of Environmental Ethics. A two-tiered exam system enables new professionals to grow within a network of accomplished individuals offering invaluable career advice and opportunity. An IPEP credential signifies that a professional is part of a network that is uniquely qualified to lead with high standards through the current shifts in economy and job market, with some recent reports indicating the Great Lakes region particularly will benefit from those projected changes. *Keywords: Organizations, Education, Economic impact.*

KOCOVSKY, P.M., USGS Great Lakes Science Center, 6100 Columbus Ave, Sandusky, OH, 44870. **Morphological Differences of Yellow Perch Across and Within Management Units in Lake Erie.**

Management of harvest of yellow perch in Lake Erie is partitioned into management units (MU) conforming loosely to ecological basins. Recent genetic evidence has revealed differences at scales finer than MU, which implies there may be discrete stocks at scales finer than MU. I examined morphometrics of yellow perch to determine if morphological differences conform to MU boundaries or if finer-scale differences in morphology exist. I conducted DFA of whole-body morphometrics of spawning male yellow perch sampled from eight different sites within each MU in 2007 and 2008. Morphometrics varied across MU. Eastern basin perch were quite morphologically distinct compared to central and western basin fish, which corroborates major differences in mitochondrial cytochrome b and microsatellites of eastern-basin fish compared to western- and central-basin fish. Morphometrics also varied across sites within MU1, MU2, and MU3. Differences among sites within MUs corroborate genetic evidence that discrete stocks may exist within MUs. Lack of replicates prevents a comprehensive examination of morphological differences within MU4. I intend to continue this work expanding to a greater number of sites in the eastern basin and to include sites in Ontario waters to further examine potential stock structure. *Keywords: Yellow perch, Stocks, Populations, Lake Erie.*

KOEHLER, N.¹, STEWART, S.¹, and SIEGGREEN, D.², ¹Michigan Sea Grant, 21885 Dunham Road, Suite 12, Clinton Township, MI, 48036; ²Hillside Middle School, 775 North Center, Northville, MI, 48167. **Teaching with the Great Lakes Observing System (GLOS).**

Science education is changing. Educators are striving to teach science the way science is done, emphasizing inquiry. Analyzing and communicating data from local research helps students to learn science process and place concepts into a real-world context. Michigan Sea Grant/Center for Ocean Science Education Excellence (COSEE Great Lakes) is developing educational materials to facilitate the use of Great Lakes Observing System (GLOS) data as tools for teaching about the Great Lakes and the oceans. GLOS is an effort dedicated to providing access to real-time and historic data on the hydrology, biology, chemistry, geology and cultural resources of the Great Lakes, its interconnecting waterways and the St. Lawrence River. Components of the systems include buoys, satellite sensors, ship observations and other

platforms. GLOS is a regional node of the US Integrated Ocean Observing System (IOOS) initiative. Teaching with GLOS materials target grades 4-10. Lessons are geared for middle school students, but include modifications for upper elementary & high school. Topics include Great Lakes seasonal cycles, productivity mechanisms, and weather and climate in the Great Lakes region. This session will provide an overview of Teaching with GLOS materials and will demonstrate how research data can be adapted for use in the classroom. *Keywords: Outreach, Education.*

KOLINSKI, C.¹ and GOREY, C.², ¹Clay High School, 5665 Seaman Road, Oregon, OH, 43616; ²Department of Chemical and Environmental Engineering, University of Toledo, Toledo, OH, 43606. **Teaching Science to Make Good Citizens.**

Our NSF GK-12 program places graduate students as mentors in high school classrooms to give students a scientific role model. With only 8% of the US population receiving science and engineering degrees, communicating the importance of science to the rest of the population can be a difficult task. The 2008 election season illustrated the importance of basic scientific principles in educating the public. In order to engage scientific thinking, it is best to allow students to formulate their own questions and answers. Inquiry-Based Learning allows students to use basic knowledge to make observations and judgments about more advanced topics. Hands-on learning allows students to connect with the material. One activity was engaging freshmen and sophomore class involvement with Student Watershed Watch. Fifty students learned basic techniques for water quality monitoring involving chemical, physical, and wildlife data. Once trained in basic methods, students went to the field and took measurements and developed an overall evaluation of the quality of the stream and its impact on the local water supply. *Keywords: Education, Public participation, Inquiry Based Learning.*

KORWEL, I., 100 Oakdale Campus #223 IREH, Iowa City, IA, 52242. **Disposition and Toxicity of PCB atropisomers - from Animal Model to Human.**

Although polychlorinated biphenyl (PCB) atropisomers undergo enantiomeric enrichment in vivo and elicit different biological responses, our understanding of the underlying mechanisms is still very limited. Several studies show an enrichment of one PCB atropisomers in rodents and humans. The extent of this enantiomeric enrichment depends on the route of exposure and the dose, but is independent of the gender and the dietary fat content. Although enantioselective binding and/or metabolism by cytochrome P450 enzymes are likely causes of PCB's enantiomeric enrichment, induction of cytochrome P-450 enzymes prior to PCB administration does not modulate the enantiomeric enrichment of PCBs in vivo. These findings have human health implications because PCB atropisomers enantiospecifically alter endpoints associated with developmental neurotoxicity, such as sensitization of Ryanodine receptors. Further studies of the biotransformation processes responsible for the enantioselective disposition of PCBs are needed to understand difference in the enantiomeric enrichment observed in laboratory studies and humans. *Keywords: Disposition, Chiral PCBs, PCBs.*

KOSLOW, M.R. and MURRAY, M.W., 213 West Liberty St., Suite 200, Ann Arbor, MI, 48104-1398. **Thinking about Great Lakes Land and Water: The Need to Integrate Land Stakeholders and Water Managers in Planning for a Changing Climate.**

Average air temperatures in parts of the Great Lakes region have increased significantly in the past few decades, and the current atmospheric CO₂ concentration is such that global average surface air temperatures are projected to continue to warm by 1.6°F or 0.9°C by 2100 even without a reduction of emissions (IPCC. 2007). Regional impacts of this warming will likely include changes in precipitation patterns, streamflow, lake levels, and water quality. A substantial area of the Great Lakes region is coastal; therefore it is important to consider the impacts on coastal communities while working towards reducing risks presented by a warming climate. Integrated decision-making between land stakeholders and water managers is needed to address these complex regional issues and will allow for efficiency while preventing extra costs. This paper will explore mechanisms that facilitate the involvement of individuals, groups and organizations related to climate change decision-making for Great Lakes coasts and help establish procedures that ensure integration. *Keywords: Decision making, Coastal wetlands, Climate change.*

KOWALSKI, K.P., U.S. Geological Survey - Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105. **Examination of Longnose Gar Movement in a Lake Erie Coastal Wetland using a High-Resolution Acoustic Camera (DIDSON).**

Longnose gar (*Lepisosteus osseus*) is one of many Great Lakes fish species that use coastal wetland habitats. Research projects in the Crane Creek coastal wetland complex (Ottawa National Wildlife Refuge) are exploring wetland habitat rehabilitation strategies and their impact on Lake Erie fish. The DIDSON (Dual-frequency IDentification SONar) is a developing technology able to collect high-resolution fisheries data day or night in very shallow turbid water. A DIDSON was deployed for 11 days in the narrow connection between Crane Creek and Lake Erie to characterize how Great Lakes fish used coastal wetland habitats. In addition to continuous DIDSON data, site data on water quality, depth, and velocity were collected. Statistical sampling and manual analysis of the DIDSON data revealed a very high density and variety of fish accessing the wetland. Because of their distinctive size and body shape, gar could be identified and their movement patterns related to changes in abiotic conditions. Although sampling and analysis techniques for this new technology are being developed, early results suggest that DIDSON data will allow an unparalleled look at fish movement and behavior in critical habitats. *Keywords: Wetlands, Hydroacoustics, Fish.*

KRANTZ, D.E.¹, NORTON, A.N.², KNAPP, J.L.¹, SPONGBERG, A.L.¹, FISHER, T.G.¹, and FULLER, J.A.³, ¹Department of Environmental Sciences, University of Toledo, Toledo, OH, 43606; ²Department of Geological Sciences, Michigan State University, East Lansing, MI, 48824; ³ODNR Division of Geological Survey, Retired, Sandusky, OH. **Upper Quaternary Stratigraphy and Post-Glacial History of Western Lake Erie.**

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

The late glacial and post-glacial stratigraphy beneath the Western Basin of Lake Erie and Maumee Bay was mapped with high-resolution chirp seismics that were correlated with lithologies from jetted holes and vibracores previously collected by the Ohio Geological Survey (OGS). Seven seismic-stratigraphic units were defined that have consistent characteristics over the basin. The seismic surveys in the open Western Basin followed the previous core transects, and boundaries between seismic units match well with lithologic contacts from the coreholes. The generalized stratigraphy, from bottom to top, is: dolomitic bedrock, till, glacio-lacustrine clay-silt, sand, and recent lacustrine. Two separate tills are identified beneath Maumee Bay, and possibly elsewhere in the Western Basin, which is consistent with OGS interpretations from on-land boreholes. The glacio-lacustrine clay-silt is associated with the glacial lakes from Maumee through Warren that occupied the Lake Erie basin. The sand unit is interpreted as fluvial deposition during the lowstand of Early Lake Erie and is thickest near the projected courses of the Huron River and River Raisin. A significant finding is the stratigraphic distinction of two discrete peat horizons above and below the sand unit, with associated radiocarbon ages of 12-10 ka and 6-4 ka, respectively. *Keywords: Paleolimnology, Seismic stratigraphy, Lake Erie.*

KRANTZBERG, G., Dofasco Centre for Engineering and Public Policy, McMaster University 1280 Main St. W, Hamilton, ON, L8S 4K1. **Indicator Endpoints Inform Active Intervention.**

When we set out on a voyage, we have a choice. We can follow impulse or we can take a map that leads us to a particular destination. For those trying to revitalize Areas of Concern, the map itself, the Remedial Action Plan, needs a legend that describes the vision for the future of the Area of Concern and its watershed. To answer the question, “where is there?” RAP participants need information that will enable them to recognize when the Area of Concern supports an ecosystem whose function has been restored. This presentation will detail methods for determining delisting criteria or endpoints. Such endpoints enabled scientists and program managers to prioritize actions and interpret the road signs that direct progress towards restoration of beneficial uses. The targets are environmental indicators. They enable scientists and policy makers to affirm whether particular interventions are able to move them closer to their destination. Specifying indicator endpoints or delisting targets that measure progress towards the goals allows the practitioners to prioritize actions and reach consensus on ecosystem response. *Keywords: Policy making, Remediation, Indicators.*

KRANTZBERG, G.¹ and MANNO, J.², ¹McMaster University, 1280 Main St. W, Hamilton, ON; ²SUNY College of Environmental Science and Forestry, Syracuse, NY. **Renovation and Innovation; It’s Time for the Great Lakes Regime to Respond.**

The current comprehensive review of the operation and effectiveness of the Great Lakes Water Quality Agreement (GLWQA) required of the federal governments of Canada and the United States was initiated with the release of the International Joint Commission's (IJC) 12th Biennial Report in 2004. The IJC began that report imploring the governments to “address a fundamental question: collectively, are policy, program and management efforts sufficient to protect water quality... in the Great Lakes basin and to ensure ecosystem integrity?” This presentation describes an exploratory and evaluative process into future options for Great Lakes

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

governance renewal. The project intent is to inform revisions to the governance and accountability structure involved in coordinating the binational Great Lakes St. Lawrence River region. The research included expert interviews and scholarly analysis of governance regimes in 2006, leading to a Great Lakes St. Lawrence River Governance Expert Work–shop held in June 2007. This presentation presents our findings. *Keywords: Environmental policy, Lake management, Policy making.*

KRAUS, D.T. and **WHITE, G.A.**, Nature Conservancy of Canada - Ontario Region, RR#5, 5420 Highway 6 North, Guelph, ON, N1H 6J2. **Status and Assessment of Terrestrial Coastal Ecosystems in the Great Lakes.**

The Great Lakes shoreline is over 28,300 km in length – making it the longest freshwater coast in the world. Terrestrial ecosystems along the coast are formed and influenced by their proximity to the Great Lakes, resulting in a very high diversity and richness of globally rare vegetation communities and species. Land use within this coastal band can have a significant influence on biodiversity and water quality within the adjacent nearshore zone. The project, prepared for the State of the Lakes Ecosystem Conference (SOLEC), provides an update to the original 1996 assessment of coastal terrestrial ecosystems. The project assembled background information and spatial data from Canada and the U.S. and created a basin-wide dataset of 14 coastal terrestrial ecosystems including sand and cobbles beaches, dunes, cliffs, bluffs, and specialized Great Lakes coastal vegetation communities such as lakeplain prairies and coastal fens. The distribution, condition, threats and conservation status of each system was analyzed and mapped based on 75 coastal units to identify priorities for coastal land protection and restoration. *Keywords: Coastal ecosystems, Conservation, Environmental health.*

KRAUSE, A.E.¹, **KASHIAN, D.R.**², **NOWELL, B.**³, **LIU, Z.**¹, **DROUILLARD, K.G.**⁴, **SANO, L.**², and **ELLISON, R.**⁵, ¹University of Toledo, Toledo, OH; ²Wayne State University, Detroit, MI; ³North Carolina State University, Raleigh, NC; ⁴University of Windsor, Windsor, ON; ⁵U.S.-Environmental Protection Agency, Great Lakes National Program Office, Grosse Isle, MI. **Network Analysis: an Evaluation Tool for the Human and Natural Systems of the Fish Consumption Advisories in the Detroit River.**

A systems approach was used to address issues involved with fish consumption advisories in the Detroit River through network analysis. The stakeholder network was identified as our human system, where stakeholders were defined as any organization that had an interest in contaminants and its human health effects in the Detroit River. The food web in the Detroit River was identified as our natural system. We used the same network analysis tools to evaluate both of these systems in terms of their structural and functional diversity at several system levels. Our analysis quantified the weak ties between U.S. and Canadian organizations, where organizations with representatives newer to the stakeholder group were less integrated. The stakeholder system also demonstrated low diversity. These factors have implications on how important issues are managed in the overall system. In a workshop, participants that represented stakeholder organizations identified their top five issues involving fish consumption advisories. The food web results contribute information for addressing two of the top five issues dealing with

contaminant levels of fish not included in the advisory and sources of contamination that are high enough to translate into fish consumption advisories. *Keywords: Ecosystems, Detroit River, Environmental contaminants.*

KREIS, R.G.¹, ZHANG, X.M.², ZHANG, X.I.N.², MURPHY, E.W.³, RYGWELSKI, K.R.¹, ROSSMANN, R.¹, WARREN, G.J.³, HORVATIN, P.J.³, and MELENDEZ, W.⁴, ¹USEPA ORD - Grosse Ile, 9311 Groh Road, Grosse Ile, MI, 48138; ²Z-Tech, 9311 Groh Road, Grosse Ile, MI, 48138; ³USEPA Great Lakes National Program Office, 77 West Jackson Blvd., Chicago, IL, 60604; ⁴Computer Sciences Corporation, 9311 Groh Road, Grosse Ile, MI, 48138. **Lake Michigan Mass Balance Study Post Audit: Integrated, Multi-media PCB Modeling and Forecasting for Lake Trout.**

The Lake Michigan (LM) Mass Balance Study was conducted to measure and model polychlorinated biphenyls (PCBs) and other anthropogenic substances to gain a better understanding of the transport, fate, and effects of these substances within the system and to aid managers in the environmental decision-making process. A series of scenario forecasts were conducted using the linked LM2-Toxics and LM Food Chain models, supported a suite of LM models. Forecasts of 5 to 6-year old lake trout for the Saugatuck region indicated that total PCB concentrations will continue to decrease and the Sports Fish Advisory Task Force's goal for unrestricted consumption could be achieved as early as the year 2033. Compared to PCB data for lake trout from the Great Lakes Fish Monitoring Program for a 10-year period, since the final year of the project in 1995, the model forecasts and data exhibit good agreement and suggest that the model forecasts are reasonable. Results are consistent with long-term decreases in all media and are subject to assumptions considering future loads, vapor phase concentrations, PCB decline rates in various media, food chain composition, and the pace of projected remedial actions. This abstract does not necessarily reflect EPA policy. *Keywords: Ecosystem forecasting, Lake Michigan, PCBs.*

KRUEGER, D.M.¹, RUTHERFORD, E.S.², TYLER, J.A.³, WILEY, M.J.¹, and MASON, D.M.², ¹University of Michigan, 440 Church St, Ann Arbor, MI, 48109-1041; ²Great Lakes Environmental Research Laboratory, 4840 S. State Rd, Ann Arbor, MI, 48108; ³Fisheries Projections, 307 Old Mountain Rd., Farmington, CN, 6032. **Using Fishery Management Activities to Forecast Species Interactions and Chinook (*Oncorhynchus tshawytscha*) Recruitment in a Large Lake Michigan tributary.**

Our goal was to use model predictions guided by empirical data to direct fishery management decisions regarding stocking and fishing regulations in the Muskegon River Estuary System (MRES), Michigan. We used established local-reach hydraulic models to simulate the biological environment in the MRES. Within this model, our individual-based model (IBM) simulated the influence of variable biotic and abiotic factors on wild Chinook recruitment in the MRES. The IBM includes mechanistic sub-models which simulate juvenile Chinook foraging, growth, movement, background daily mortality and predation mortality. To parameterize the model we used empirical data on management activities (i.e. river temp and flow via dam regulation, predator stocking rates, stocking dates and fishery regulations), wild age-0 Chinook

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

abundance, alternate prey abundance, total predator abundance and predator diet compositions. Model simulations began with spawning of adults, and continued through the egg, fry, parr and smolt stages. We ran the IBM to simulate 50-year periods, which reflected variable environmental conditions and variable predator and alternate prey abundances. Simulations show fairly strong changes in potential age-0 Chinook recruitment due to various management practices in the MRES. *Keywords: Management, Recruitment, Salmon.*

KUSNIER, J., Mannik & Smith Group Inc., 1800 Indian Wood Circle, Maumee, OH, 43537.

Wetland and Riparian Inventory and Restoration Plans for Swan Creek and Ottawa River.

This project addresses some of the areas within the Maumee Basin that have been heavily affected by past industrial activity. Among other challenges, this area has lost wetlands that once filtered sediment and nutrients before they reached Lake Erie. Mitigation funds often become available (as part of the requirement for a new permit, for a road improvement project, or other construction), but unless a list of potential mitigation projects has been prepared, it is not possible for the watershed to claim those funds. This project is to identify and prioritize up to fifteen potential wetland and/or riparian mitigation sites in both the Swan Creek and Ottawa River watershed located with the Toledo area, Ohio. A GIS based model was developed in order to identify preliminary priority sites for wetland, stream and isolated wetlands within both watersheds. Sites were identified in three regions with the watersheds: urban, agricultural/rural and the Oak Openings. Further refinement of the model and consultations with the project management team allowed for the selection of final sites that were then subject to field validations. Individual site plans were then created for each site to allow for a range of future potential enhancement, restoration, conservation and mitigation opportunities.

Keywords: Watersheds, Ecosystems, Management.

LAND, M.D., Environmental Consortium of Hudson Valley Colleges & Universities, 78 North Broadway, White Plains, NY, 10603, United States. **Regional Consortia in Higher Education: Collaborative Ecosystem-Based Teaching and Learning in the Hudson River Watershed.**

Today's environmental challenges require a sophisticated, coordinated approach that simultaneously crosses academic disciplines, engages policy makers and educates the public. Networks of campuses throughout the continent are using regional or ecosystem-based collaborations to advance environmentally related goals among their institutions and within local communities. Consortia are capable of bringing together the various perspectives necessary for creating regional and global strategies that are environmentally, socially, economically, and politically sustainable. By sharing resources and expertise, collaborative consortia can accomplish collectively what no one institution could do on its own. The Hudson River watershed region is uniquely rich in its culture, history, and natural systems. An equally rich intellectual bank of scholars and experts with diverse perspectives interpret and convey this region's story creating an accessible living, learning laboratory. Connecting students with the immediacy and significance of what is happening in our own region fosters linkages of theory to local places, people, and practices. This presentation will discuss the Environmental Consortium

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

of Hudson Valley Colleges & Universities—our beginnings, goals, programs, and the organizational/institutional challenges addressed along the way. *Keywords: Ecosystem-based, Collaborative, Consortium.*

LANGEN, T.A. and TWISS, M.R., Great Rivers Center, Clarkson University, Potsdam, NY, 13699-5805, United States. **Importance of Field Research Stations for Great Lakes Research – an Assessment Focusing on Published Research Productivity.**

Field research stations in the Laurentian Great Lakes include both shore-based installations that provide lodging, lab space, and access to the water, and mobile research vessels large enough to provide lodging and work space for researchers. Expenses of field stations can be justified if they result in a sufficiently high volume of quality published research. The relative importance of field stations for facilitating Great Lakes research by examining all papers published on the Great Lakes watershed (from Lake Superior through the International Section of the St. Lawrence River) in three representative journals: *Limnology and Oceanography*, *Canadian Journal of Fisheries and Aquatic Science*, and *Journal of Great Lakes Research* and analyzing oral presentation from IAGLR at 50 in 2007. For each paper, we determined whether field station – based research contributed to the project by examining the institutional affiliations of authors, the methods section, and the acknowledgments. From these patterns of research productivity, and from the geographic distribution of currently operating field stations, we make some tentative conclusions about whether new field stations are warranted, and geographically where there may be greatest need for new facilities. *Keywords: Field stations, Great Lakes basin, Observing systems.*

LASHAWAY, A.R. and CARRICK, H.J., School of Forest Resources, Pennsylvania State University, University Park, PA, 16802. **Spatial and Temporal Variation of Diatom Physiological Condition in Lake Erie Benthos: Implications for Seasonal Hypoxia.**

Rapid sedimentation of phytoplankton cells following surface blooms is common in the Great Lakes, yet their fate is uncertain, particularly in Lake Erie, where hypoxia occurs seasonally. Seasonal sampling was done for the benthos at stations inside and outside of the hypoxic area in the central basin of Lake Erie (winter, spring, summer, fall). Variation in chlorophyll-a concentrations, physiological condition (cell viability), and rejuvenation rates (from enclosure experiments) were examined. During summer stratification we expect the oxygen rich areas to support lower chlorophyll-a concentrations, faster diatom rejuvenation rates, and superior physiological capabilities, compared with those of hypoxic environments. The results confirmed that hypoxic areas do sustain higher chlorophyll-a, but little to any significant difference in the diatom growth and physiological capability was observed. Hypoxic areas were observed to support growth rates as high as 0.56 per day (compare with oxic site at 0.53 per day) and physiological conditions as high as 0.31 $\mu\text{g/L/day}$ (compare with oxic site at 0.36 $\mu\text{g/L/day}$). If diatoms are able to withstand low oxygen concentrations, (not a contribution to decomposition) and ultimately rejuvenate into fully operating vegetative cells, they may not be the main culprit to hypoxic conditions. *Keywords: Benthos, Hypoxia, Diatoms.*

LAVELLE, K.M.¹ and MATISOFF, G.², ¹Hathaway Brown School, 19600 N Park Bl, Shaker Heights, OH; ²Department of Geological Sciences, Case Western Reserve University, Cleveland, OH, 44106-7216. **Sediment Oxygen Demand in Lake Erie.**

Thermal stratification in Lake Erie during the summer causes a variety of water quality problems, including bottom water hypoxia. This project is to measure the rates of oxygen depletion in the central basin of Lake Erie. Two procedures were used: whole core incubations and oxygen microelectrode profiling. Whole core incubations involved the collection of short (~15 cm) sediment cores in BOD bottles that were sealed and incubated in a constant temperature bath in the dark. A control consisted of only Lake Erie bottom water. The oxygen concentration was monitored by computer every minute for 12 hours and the depletion rate was calculated from the linear decrease in oxygen concentration with time. Microelectrode profiling is measured using a micro-oxygen electrode. The electrode is mounted onto a precision screw slide and inserted into the sediment at a rate of 0.1 centimeters every 30 seconds and the oxygen concentration recorded. Nitrate and pH were measured simultaneously using microelectrodes. The oxygen demands determined by the two methods (~0.1-0.2 g O₂/m²/d) are in reasonable agreement with each other and are comparable to those reported by Smith and Matisoff (2008). The results can be used to improve estimates of sediment oxygen demand (SOD) and internal chemical loading into Lake Erie waters. *Keywords: Oxygen, Sediments, Lake Erie.*

LAWRENCE, P.L., Dept of Geography & Planning, University of Toledo, Toledo, OH, 43606. **Projects in the Maumee Area of Concern: An Overview of Partners for Clean Streams.**

Partners for Clean Streams, Inc. was established in 2007 with a mission to strive for abundant open space and a high quality natural environment; adequate floodwater storage capacities and flourishing wildlife; stakeholders who take local ownership in their resources; and rivers, streams, and lakes that are clean, clear and safe. In 2007 the Joyce Foundation has selected the Partners for Clean Streams (PCS)/Maumee RAP (RAP) to receive funding for a three-part project that will assist in fulfilling its goal of restoring the beneficial uses of the Maumee Area of Concern (AOC). This goal will be accomplished with the completion of a human health and ecological risk assessments for Duck Creek and Otter Creek, the mitigation of a low-head dam in Swan Creek, and the creation of inventory and restoration plans for Swan Creek and the Ottawa River. Conducting these projects will assess the possibility of an adverse health affect due to the potential exposure to contamination in Duck or Otter Creeks, restore flow and improve in-stream and riparian habitat on Swan Creek, and identify sites in the Swan Creek and Ottawa River watershed that if restored could improve aquatic habitat, increase biodiversity, restore hydrology, and reduce pollutant loadings. *Keywords: Watersheds, Ecosystems, Planning.*

LAWRENCE, T.J., School of Natural Resources and Environment, University of Michigan, Ann Arbor, MI, 48109. **Understanding Fisher's Behavior under Co-Management Institution: Defining Challenges of Fisheries Management on Lake Victoria, East Africa.**

Recent trends in fisheries resource management in East Africa have recognized the crucial role of local communities. Through co-management institutions, formal rules have been developed to guide sustainable fisheries practices for the purpose of regeneration of fish stocks, and permitting sustainable livelihoods of the communities who depend on them. Illegal fishing, however, continues despite these fishing rules, and jeopardizes the long-term sustainability of the fishery and economic viability of the fishing communities. The objective of this research is to identify the factors that have enabled the destructive fishing practices of fishers which formal rules have trouble overcoming. This research will: 1) explore the relationships between formal fishing rules and the influence that informal factors have on behavior of fishers that undermine those rules, 2) isolate those key factors that influence fishing behavior amongst fishermen, and 3) determine through statistical analysis, the magnitude, relative contribution, and direction of influence those identified factors have on the ability, or desire, of fishers to follow established formal fishing rules. Preliminary results indicate numerous and complex factors, including lack of enforcement of rules, strong market pressures, and judicial weaknesses within the institutions. *Keywords: Africa, Lake management, Lake Victoria.*

LAWSON, G.¹, DOVE, A.², BACKUS, S.², and MUIR, D.C.G.¹, ¹Environment Canada, Aquatic Ecosystem Protection Research Division, Burlington, ON, L7R 4A6; ²Environment Canada, Water Quality Monitoring and Surveillance, Burlington, ON, L7R 4A6. **Whole Water Total-Mercury Concentrations in the Great Lakes.**

Total-mercury (THg) concentrations have been determined in all of the Great Lakes, with the most recent surveys conducted between 2006 and 2008. Ultra-clean methods, including clean-lab and ISOMET (Isolation Strategy for Metals), were used to obtain water during ship-based surveys of the lakes. In the open waters, the concentrations of THg generally fall within a relatively narrow range from about 0.3 to 1 ng/L. Despite this narrow range, some spatial patterns emerge upon closer inspection of the data. The recent average open lake concentrations of THg were (from lowest to highest) 0.24 ng/L in Georgian Bay (2007), 0.31 ng/L in Lake Huron (2007), 0.41 ng/L in Lake Superior (2005), and 0.48 ng/L in both Lake Ontario (2005) and Lake Michigan (2006). Values in Lake Erie are higher, particularly in the western basin, where the average concentration of THg was 4.98 (2004) and 3.86 ng/L (2006). More detailed information is available for Lakes Erie and Ontario, including depth profiles and some seasonal information. Concentrations of THg appear, in general, to be higher in the epilimnion than the hypolimnion. In the western basin of Lake Erie, suspended sediment near the sediment-water interface, as well as resuspension events, influenced observed concentrations. *Keywords: Mercury, Spatial distribution, Water quality.*

LEBLOND, S.S.M.¹, HAMILTON, K.¹, RUTTER, A.², and CAMPBELL, L.M.³, ¹Department of Biology, Queen's University, Kingston, ON, K7L 3N6; ²Analytical Services Unit, Department of Environmental Studies, Queen's University, Kingston, ON, K7L 3N6; ³Department of Biology & Department of Environmental Studies, Queen's University, Kingston, ON, K7L 3N6. **Sediment Metal Concentrations within the UNESCO Designated Rideau Canal.**

The Rideau River Waterway is UNESCO World Heritage Site comprised of a series of lakes connecting Ottawa to Kingston, ON. In 2006, a preliminary study evaluated metal concentrations in sediment and water from nine of these lakes. The mean sediment concentrations exceeded Canadian Federal guidelines (in brackets) for Cd (0.6 ppm), Hg (0.17 ppm), Pb (35 ppm) and Zn (123 ppm) within each of the studied lakes and Cu (35.7ppm) within all but one lake. The three lakes with the highest overall metal concentrations were further sampled in 2007 and 2008. The mean concentrations for Cd, Hg, Pb and Zn, the primary elements of concern, ranged between 1.2 -1.8 ppm; 0.12 - 0.16 ppm; 65 – 180 ppm; and 123 – 150 ppm, respectively for grab samples. Concentrations from the top of sediment cores ranged between 1.1 – 3.3 ppm; 0.15 – 0.52 ppm; 54 – 327 ppm; and 128 – 306 ppm, respectively. With the high rate of recreational use, especially for sport fishing, it is imperative to recognize the rate of metal influx to the system in order to protect both human and aquatic health. The objectives of this study are to examine the relationships and movement of metals between different matrices within a highly complex and human managed system. *Keywords: Urban watersheds, Environmental effects, Sediments.*

LEE, P.F., Dept. of Biology, Lakehead University, Visiting Scientist, Royal Botanical Gardens, Thunder Bay, ON, P7B 5E1. **Re-introduction of Southern wild rice, *Zizania aquatica* L., into Cootes Paradise, Lake Ontario.**

Once an abundant macrophyte in Cootes Paradise, southern wild rice was gradually extirpated over the past century primarily due to the introduction of carp which reduced water clarity and uprooted developing plants. In 1997, the construction of a fishway at the entrance to the marsh that excludes carp enabled vegetation to again colonize the wetland. Efforts by the Royal Botanical Gardens (RBG) to re-introduce southern wild rice began in 2000. Initial characterization of the marsh showed that sediment quality and depth regimes were still suitable for the production of southern wild rice. Test plantings in Cootes were successful and full scale rehabilitation of the species began in 2003. The wild rice was initially started in protective enclosures at four sites within the marsh that excluded any remaining carp and waterfowl. Production of southern wild rice varied but was excellent at two of the sites. Relocation of some of the enclosures has since occurred and a self sustaining population of southern wild rice is now present in Cootes Paradise. Southern wild rice was also the main species in other wetlands in the lower Great Lakes, and the techniques developed in this study can be applied elsewhere to re-establish this once abundant native plant species. *Keywords: Wild rice, Lake Ontario, Marshes.*

LEGLER, N.L.¹, JOHNSON, T.B.², HEATH, D.D.¹, and LUDSIN, S.A.³, ¹Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, N9B 3P4; ²Ontario Ministry of Natural Resources, Picton, ON, K0K 2T0; ³The Ohio State University, Columbus, OH, 43212. **Influence of River Plumes on Feeding of Lake Erie Fishes.**

Our research evaluates predator-prey relationships in Lake Erie and the effects of watersheds, through river inputs, on prey consumption. Habitat heterogeneity associated with inputs of nutrient and sediment rich water from the Maumee River and comparatively nutrient poor, clear water from the Detroit River were expected to influence foraging behaviours of fishes

by influencing prey availability and visual acuity. White perch, yellow perch, white bass, and walleye were collected from each river plume during 2006 and 2007 and stomach contents were compared between plumes and years. Diet analyses revealed spatial and temporal variability in prey consumption; zooplankton was generally more important in the Maumee plume, whereas forage fish were important in the Detroit plume. These results were consistent with differences in prey availability and nutrient and sediment concentrations between plumes and were likely driven by inputs from tributary streams. Our findings demonstrate that biological and physico-chemical attributes can simultaneously produce distinct patterns in productivity and feeding behaviours. Knowing that watershed-scale effects can drive fundamental differences in predator-prey interactions is an important step towards developing watershed-based approaches to fisheries management. *Keywords: Fish diets, Lake Erie, Tributaries.*

LEKKI, J.D.¹ and LESHKEVICH, G.A.², ¹NASA Glenn Research Center, Brook Park, OH; ²NOAA Great Lakes Environmental Research Lab, Ann Arbor, MI. **Airborne Monitoring of *Microcystis* Blooms in Lake Erie.**

The NASA Glenn Research Center (GRC) and NOAA Great Lakes Environmental Research Laboratory (GLERL) are collaborating to utilize an airborne hyperspectral imaging sensor suite to forecast and monitor Harmful Algal Blooms (HABs) in the western basin of Lake Erie and Saginaw Bay in Lake Huron. The HABs are very dynamic events and are a concern for human health, fish and wildlife because they commonly contain a potentially toxic alga, *Microcystis*. *Microcystis* can contain the toxin microcystin. In the Great Lakes one of the most common forms of microcystin is Microcystin-LR, which also happens to be one of the most toxic forms of microcystin. Because of this potential toxicity there is a need for the blooms to be detected early and continually monitored. A small lightweight Hyperspectral Imaging System (sensitive in the visible and near infrared portion of the spectrum) has been developed by engineers at the National Aeronautics and Space Administration's (NASA) Glenn Research Center (GRC) and the Ohio Aerospace Institute (OAI). Mounted on a NASA aircraft the system was flown over western Lake Erie in September of 2007 while in situ water samples were collected. Results show that we can detect and map *Microcystis* blooms. Future work includes flying the sensor on an unmanned vehicle. *Keywords: Microcystis, Remote sensing.*

LENTERS, J.D.¹, HOLMAN, K.D.², and WANG, J.¹, ¹University of Nebraska-Lincoln, Dept. of Geosciences and School of Natural Resources, Lincoln, NE, 68583; ²University of Wisconsin-Madison, Department of Atmospheric and Oceanic Sciences, Madison, WI, 53706. **Recent Enhancement of Surface Water Temperature Trends and Evaporation in a Northern Wisconsin Lake: Response to a Sunnier Climate?**

Increases in water temperature, reductions in ice cover, and increases in evaporation are just a few examples of the observed physical response of lakes to a warming climate. Interestingly, some lakes appear to be warming faster than the regional air temperature, suggesting that lakes may be "hypersensitive" to climate change. Suggested mechanisms for this enhanced lake warming include ice-albedo feedbacks and earlier onset of spring/summer stratification. To examine the physics of this process in more detail, we investigate the climate

and energy balance of Sparkling Lake (in northern Wisconsin, USA) over a 25-year period. Similar to nearby Lake Superior, the summertime surface water temperature of Sparkling Lake has been warming more rapidly than the regional air temperature. Unlike Lake Superior, however, Sparkling Lake is much shallower and does not show a pronounced connection between interannual variations in spring ice-off dates and eventual mid- to late-summer water temperatures. Rather, we find that the region has experienced a significant upward trend in incoming solar radiation, primarily as a result of reductions in cloud cover. Given the regional nature of the observed trends in cloud cover, the results of this study may have significant implications for other lakes throughout the area, including Lake Superior.

Keywords: Atmosphere-lake interaction, Climate change, Lake Superior.

LEON, L.F.¹, SMITH, R.E.H.¹, HIGGINS, S.¹, HIPSEY, M.R.², DEPEW, D.C.¹, MAILKIN, S.¹, and YERUBANDI, R.³, ¹University of Waterloo, Waterloo, ON; ²University of Western Australia, Perth, Australia; ³National Water Research Institute, Burlington, ON. **Nested Modeling for Nearshore Water Quality and Algae Growth in Lake Ontario.**

Despite reductions of phosphorus loading to the Great Lakes in the last decades, the benthic algae *Cladophora* has once again become sufficiently abundant to be a serious water quality nuisance. In this study we extended the work started in the nearshore modeling on Lake Erie to couple a mechanistic model of *Cladophora* growth into a 3D hydrodynamic-ecological model in order to simulate the water quality conditions in the vicinity of the Pickering Nuclear Power Plant. The model was able to capture the main variations of *Cladophora* biomass accumulation across the area and the timing of major detachment events was reasonably approximated. The model confirms indications from site-specific data that both P supply and light availability are critical factors in algal success and suggests that algal growth can be prolific even without invoking local nutrient inputs. *Keywords: Hydrodynamic model, Water quality, Lake Ontario.*

LESHKEVICH, G.A.¹ and LIU, S.², ¹NOAA/Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108; ²Cooperative Institute for Limnology and Ecosystem Research, 4840 South State Road, Ann Arbor, MI, 48108. **CoastWatch Great Lakes Program Update: 2009.**

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>). Utilities such as JAVA GIS and Google Earth(R) allow interactive retrieval of physical parameters such as surface water temperature, ice cover, and modeled winds at a given location and enhance the accessibility and utility of Great Lakes CoastWatch data. Plans include enhancing the present product suite with

new near real-time satellite derived image products such as wind fields, ice type mapping, turbidity, and chlorophyll and testing a new enhanced server for improved delivery of CoastWatch products. *Keywords: Remote sensing, Satellite technology, Monitoring.*

LIAO, Q.¹, ANDERSON, J.D.², and WU, C.H.², ¹Department of Civil Engineering and Mechanics, University of Wisconsin-Milwaukee, Milwaukee, WI, 53211; ²Department of Civil and Environmental Engineering, University of Wisconsin-Madison, Madison, WI, 53706. **In Situ Measurements of Sediment Resuspension Using an Underwater Miniature Particle Image Velocimeter (UWMPIV).**

Small-scale hydrodynamics in environmental fluid flows, i.e., in rivers, lakes, oceans and wetlands, is an important factor that controls and limits many environmental transport processes, especially those near a physical interface such as the water-sediment interface, air-water interface, and water-vegetation interface. Traditional turbulent velocity measurements in field studies are usually limited to one point or along a line in space, and they lack the resolution to characterize the turbulence at dissipative scales. We have developed a self-contained Underwater Miniature Particle Image Velocimetry (UWMPIV) system to facilitate research on small-scale turbulence in the vicinity of environmental interfaces. The UWPIV employs a compact continuous-wave (CW) laser and an optical scanner to deliver a light sheet that illuminates naturally occurring particles. Particle images are taken by a CCD camera along with an ultra-compact PC. The non-tethered and compact design can be fit in two small underwater housings with all components powered by batteries: an ideal design for a variety of in situ deployments. The system has been field-tested in the coastal zone of Lake Michigan and in the estuary of Sheboygan River. Turbulent flow structures of the bottom boundary layer are measured right above the riverbed. Vertical profiles of mean *Keywords: Hydrodynamics, Coastal processes, Data acquisition.*

LIEBIG, J.R. and VANDERPLOEG, H.A., NOAA Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108. **Clearance Rate Response to Temperature by Lake Michigan Profunda Morph Quagga Mussels.**

It is well known that Dreissenid mussels have had a tremendous impact on the Great Lakes since their introduction in the late 1980s. Zebra mussels started the invasion and, in the past several years, quagga mussels have replaced them on hard substrates and have expanded into all depth zones, including soft substrates. The impact of quagga mussels spatially and temporally is an important part of any Great Lakes ecosystem forecast, and the quagga mussel's ability to filter water is a major factor in their impact. The long siphons of the profunda morph quagga may be a useful adaptation on soft substrates. Since profunda morph mussels are found at all depth zones of Lake Michigan, the mussels are exposed to wide range of temperatures seasonally. Presumably, mussel clearance rate is a function of filter area and ciliary beat rate, which is temperature dependant. We performed laboratory feeding experiments using profunda morph mussels from Lake Michigan at various temperatures to observe their functional response of clearance rate to temperature. Preliminary results generally showed a positive correlation between temperature and clearance rate, but there was much more variability than expected.

Mussels are abundant enough at most depth zones to have a significant impact on phytoplankton even at low temperatures. *Keywords: Dreissena, Lake Michigan, Mussels.*

LIMBURG, K.E.¹, LUZADIS, V.A.¹, RAMSEY, M.¹, SCHULZ, K.L.¹, and MAYER, C.M.²,
¹State University of New York, College of Environmental Science and Forestry, Syracuse, NY, 13210; ²Lake Erie Center and Department of Environmental Sciences, University of Toledo, Oregon, OH, 43618. **The Good, the Bad, and the Algae: Perceiving Ecosystem Services and Disservices Generated by Zebra and Quagga Mussels.**

Dreissenid (zebra and quagga) mussels are recognized as having adverse ecological and economic impacts, e.g. biofouling and loss of pelagic primary production. We assessed perceptions and values associated with two less often considered ecological outcomes of dreissenid influences on coastal ecosystems along Lake Ontario and the western St. Lawrence River in New York State. One, increased water clarity, we define as an ecosystem service; the other, large amounts of nuisance algae is defined as an ecosystem disservice. Surveys of business owners and homeowners quantified these preferences and the formation of values regarding these products of dreissenid mussel influence. Water clarity increased greatly, particularly in the eastern portion of Lake Ontario, and algal problems increased throughout. Businesses attributed increases and decreases in revenues associated with water clarity and algae; homeowners reported analogous changes in property values. Threshold responses of costs as functions of filamentous algae were evident. Given the likely continued influx of invasive species due to human activities, further development of the ecosystem service concept should consider potential “goods” and “bads” of invasives and their influence on ecosystem and social system resiliency. *Keywords: Zebra mussels, Exotic species, Economic evaluation.*

LIN, Y.T., WU, C.H., and FRATTA, C., 1261b Engineering Hall, 1415 Engineering Dr, Madison, WI, 53705. **A Combined Geophysical Technique to Monitor Changes of Nearshore Environment in Great Lakes.**

Several geophysical instruments including a sub-bottom profiler (SBP), a ground penetrating radar (GPR), and a sidescan sonar (SSS), is combined to obtain bathymetry, surficial sediment and sediment sublayers in the nearshore environment. Specifically a new integrated algorithm using SBP and GPR reflected signals is developed to estimate sediment porosity. SSS attached with an underwater camera improves the delineation and observed surficial sediment features. The combined instrument is applied to two locations in the Great Lakes at several times. In a closed coastal structure like Little Sand Bay Harbor in Lake Superior, it is found that sediment brought by the westernward current deposited in the east side of the harbor. Outside the harbor, no significant change of bathymetry profiles was observed. Changes of sediment porosity were obtained, providing the information of sediment erodibility. In Lake Michigan, the combined instrument package is used to survey the nearshore areas where the newly built coastal revetment in the Concordia University, Wisconsin. Bathymetry profiles and sublayers in the structured areas and the unstructured areas are compared. It is found that lakebed downcutting seems to accelerate after the completion of coastal structures. Overall the combined geophysical

instrument with the new integrated algo *Keywords: Geophysical technique, Sediment transport, Coastal structure.*

LITCHMAN, E., EVANS, M.A., DE TEZANOS PINTO, P., and KLAUSMEIER, C.A., 3700 E Gull Lake Dr, Kellogg Biological Station, Hickory Corners, M, 49060. **Trait-based Approaches to Harmful Algal Blooms.**

Trait-based approaches are being increasingly used in terrestrial ecology to explain and predict distributions of different taxa along environmental gradients. Here we show that this approach can be applied to understanding the occurrences of Harmful Algal Blooms (HABs) in diverse water bodies. We analyze major functional traits of HAB species (mostly cyanobacteria) such as cell size, nutrient and light requirements and grazer resistance. There are significant differences in trait values between HAB species and other major taxa. For example, in cyanobacteria growth rates tend to saturate at lower irradiances compared to other groups. Using the EPA NES data, we also analyze patterns of HAB species distributions along major environmental gradients. Finally, we show that merging the trait data and species distributions data improves mechanistic understanding of the environmental controls on and allows better predictions of HABs. *Keywords: Cyanophyta, Nutrients, Harmful algal blooms.*

LIU, W. and LAMB, K.G., University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1, Canada. **Poincare Waves and Kelvin Waves in a Circular Lake.**

Internal waves in lakes are studied thoroughly in literature, but most assume a hydrostatic pressure balance. Here we discuss internal Poincare waves and Kelvin waves in a rotating, flat-bottom, circular lake with fully nonlinear and non-hydrostatic effects. A set of analytical solutions is derived for the linearized system and these provide initial conditions used in the MIT General Circulation Model (MITgcm). This model was chosen due to its non-hydrostatic capability. Both Poincare waves and Kelvin waves are considered. As the wave amplitude increases the waves become more nonlinear. Poincare waves steepen and generate solitary waves with shorter wavelength, but most of the energy contained in these waves is transferred back and forth between the parent wave and the solitary waves. Kelvin waves, on the other hand, steepen and lose their energy to solitary waves. This conclusion agrees with de la Fuente et al. (2008). *Keywords: Waves, Internal waves, Model testing, Lake model.*

LIUKKONEN, B.¹, MEYER, N.², and SEIDEL, W.³, ¹MN Sea Grant, 173 McNeal Hall/1985 Buford Ave, St. Paul, MN, 55108; ²U of MN Extension, Cloquet Regional Center, 179 University Road, Cloquet, MN, 55720; ³Lake County Extension, 601 3rd Ave, Two Harbors, MN, 55616. **Impacts of a Conservation Field Day for Youth.**

Many communities around Lake Superior sponsor conservation field days for elementary students. To assess the educational effectiveness and impacts of field days, we conducted a case study in Lake County, MN. All county 6th graders attend a one-day event to learn about natural resources of their region. We surveyed all county 7th, 9th, and 11th graders (n=352) about what

they learned at the field day, and asked if they perceived doing anything differently as a result of the event. Most students remembered the event (e.g., 81% of 11th graders in Silver Bay), and many were able to recollect learning something new. 25% percent said they did something different in their lives after attending the field day. Almost all (96%) said they continue that behavior change. Students indicated participating in the event influenced their thoughts about college (46%) or career (19%). We also held focus groups with students, teachers and presenters. Students reliably described behavior changes and details about what they learned, and underscored the importance of the sense of place in increasing their awareness about the value of natural and cultural resources. Teachers integrate the field day into their curriculum. Presenters said it helps them accomplish the goals of their profession, achieve county priorities, and introduce students to career *Keywords: Education, Outreach, Lake Superior.*

LOFGREN, B.M.¹ and WILBARGER, J.², ¹NOAA/Great Lakes Env Res Lab, 4840 S. State Rd., Ann Arbor, MI, 48108; ²U. of Michigan/CILER, 4840 S. State Rd., Ann Arbor, MI, 48108.

Global Models with a Little More Evapotranspiration Drive Regional Models With Much More?

General circulation models (GCMs) and regional climate models (RCMs), in simulating future climate scenarios, calculate through parameterizations such basic hydrologic variables as evapotranspiration (ET), soil moisture, infiltration, and runoff as intermediate results. However, regional hydrologic impacts of climate change are regularly assessed using off-line hydrologic models that make no direct reference back to these predictions, but instead use other variables (primarily air temperature) as proxies to compute ET. We compared the change in ET between near-present-day and future scenarios of greenhouse gas concentration as computed within several GCMs to that computed using an off-line hydrologic model driven by the air temperatures predicted by the same GCMs. The annually averaged change in ET as predicted by the off-line hydrologic model was an increase of greater magnitude than in the GCM, typically by a factor of 3-5. Because of latent heat flux's role in the land surface energy budget, such a discrepancy in ET rates should be expected to be a significant factor in determining the temperature of the surface, as well as the air adjacent to it. *Keywords: Watersheds, Climate change, Hydrologic budget.*

LOFGREN, B.M., NOAA/Great Lakes Env Res Lab, 4840 S. State Rd., Ann Arbor, MI, 48108.

Building a Bridge in the Face of Uncertainty: Connecting Climate Change Science with Public Needs.

Climate change due to increasing concentrations of greenhouse gases such as carbon dioxide is expected to exert important influences on the Great Lakes basin. The importance of understanding this and responding to it is great, both for policymakers and the general public. At the same time, anticipation of overall climate effects has a significant degree of uncertainty to it, especially when focused at the regional and local level. The uncertainty is only exacerbated when attempting to anticipate the impacts on various ecological and socioeconomic sectors, and devising adaptation measures. Rather than attempting to be a how-to, this presentation will to

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

illuminate some of the issues along these lines, along with strategies for two-way communication between scientists and stakeholders. *Keywords: Climate change, Public education.*

LOHNER, R.N. and STEPIEN, C.A., The University of Toledo-Lake Erie Center, 6200 Bayshore Rd, Oregon, OH, 43618. **Developing an Environmental Science Learning Community at the Land- Lake Ecosystem Interface.**

Our Gk-12 program is in year one, "Graduate Fellows in High School STEM Education: An Environmental Science Learning Community at the Land-Lake Ecosystem Interface". We are building a learning community and interfacing with an existing High School Student Watershed Watch program. The latter has been in place for 18 years, was formulated by a former University of Toledo professor (Dr. Peter Fraleigh, now deceased) and is coordinated by the Maumee River Remedial Action Plan (<http://www.maumeerap.org/SWW.html>). The SWW annual program features water quality and macroinvertebrate data collection on a designated collection date in October of each year from schoolyard stream sites, and the high school students then present their findings at an annual conference in November that is held at the Toledo Zoo. We are enhancing this program by increasing the quality of the student presentations and sampling, and including additional classroom activities. We thus present and discuss our program plans for sponsoring high school science fair projects and student research posters, and approaches for engaging the students in research. *Keywords: Outreach, Environmental education, Water quality.*

LOHNER, R.N.¹, STEPIEN, C.A.¹, MOORHEAD, D.L.², BRIDGEMAN, T.B.¹, FISHER, T.G.², and GRUDEN, C.L.³, ¹The University of Toledo, Lake Erie Center, Oregon, OH, 43618; ²The University of Toledo, Department of Environmental Sciences, Toledo, OH, 43606; ³The University of Toledo, Department of Civil Engineering, Toledo, OH, 43606. **Graduate Teaching Fellows in STEM High School Education: An Environmental Science Learning Community at the Land-Lake Ecosystem Interface.**

Our NSF funded GK-12 program titled, Graduate Teaching Fellows in STEM High School Education: An Environmental Science Learning Community at the Land-Lake Ecosystem Interface partners advanced graduate students at the University of Toledo with high school teachers and their students. The objectives are: 1) Generate student enthusiasm for science careers by engaging them in hands-on research into environmental problems, 2) Exchange knowledge and pedagogies between graduate students and high school teachers resulting in cutting-edge environmental science content and increased teaching and communication skills, and 3) Develop hands-on solutions to environmental problems along schoolyard stream ecosystems feeding the Great Lakes. Participants are gaining 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; disseminated through the project website, presentations, and publications. Our schools encompass an urban-suburban-rural gradient, and projects focus on augmenting an existing Student Watershed Watch program that samples water quality in schoolyard streams. This program embraces the public scholarship philosophic concept of

merging scientific research with civic responsibility to benefit the public and the community.

Keywords: Environmental education, Monitoring, Outreach.

LOOPE, W.L.¹, GOBLE, R.J.², LOOPE, H.M.³, and FISHER, T.G.⁴, ¹U.S. Geological Survey, N8391 Sand Pt. Rd. PO Box 40, Munising, MI, 49862; ²Dept of Geosciences, University of Nebraska, Lincoln, NE, 68512; ³Dept of Geography, University of Wisconsin-Madison, Madison, WI, 53703; ⁴Dept of Environmental Sciences, 2801 W. Bancroft, MS 604, Toledo, OH, 43606. **Mid-Holocene Dune Stabilization in Interior Eastern Upper Michigan: A Response to Biogeomorphic or Physical Agents?**

Recent optical (OSL) dating of quartz sand from 19 parabolic dunes, along a strong paleoshoreline in interior eastern Upper Michigan (EUM), shows a peak of stabilization ~8.8 ka, just after the fall of Lake Minong. However, many dunes of EUM occur in settings clearly unrelated to shorelines of glacial lakes. We obtained 54 additional optical ages from dunes in a variety of settings in EUM. Our composite OSL chronology (n = 75) shows peaks of dune stabilization at 9.8, 8.6 and 7.8 ka. While the earlier peaks may be related to the history of glacial lakes, the most recent occurs ~1,000 years after levels of the upper Great Lakes had fallen to very low levels. Multiple paleoecological investigations suggest that most of EUM was forested throughout the Holocene thus yielding little or no sand nourishment. Patchy early Holocene "state shifts" (closed pine forest to pine savannah) are documented (Lytle, 2005), but these were small (~300 ha) and short-lived (200-300 years) and dune forms are absent. Punctuated increases in shrub pollen within paleosavannahs suggest a flora well-adapted to fire. Dunes apparently stabilized ~7.8, even as aridity and fires peaked. Spatial arrangement of several paired OSL ages suggests initial dune building could have set the stage for formation of younger dunes during dry times. *Keywords: Vegetation, Dunes, Drought, OSL, Holocene, Eastern Upper Michigan.*

LOWE, R.L.¹, WOLLER-SKAR, M.M.¹, JOHANSEN, J.R.², and MINER, J.G.¹, ¹Department of Biological Sciences, Bowling Green State University, Bowling Green, OH, 43403; ²Department of Biology, John Carroll University, Cleveland Hts., OH, 44118. **Benthic Algal Community Structure on Soft Sediments in Western Lake Erie.**

We sampled epipsammic and epipellic benthic algae across 23 sites in far western Lake Erie to study patterns of distribution and density of prolific populations. Habitat variables were also measured (pH, conductivity and depth). Here we report the density and distribution of three invasive species. The blue green alga or cyanobacterium *Plectonema wollei* Farlow ex Gomont (*Lyngbya wollei* Farlow) reached the highest densities in our survey. In addition to distribution data of this alga taxonomic issues will be discussed (molecular research in progress). A filamentous cyanobacterium new to Lake Erie, cf. *Sirocoleum* sp., was present in moderate abundance in areas where *Plectonema* was reduced or absent. This may be a new species and molecular definition is required. *Pleurosira laevis* (Ehrenberg) Compère, a diatom characteristic of high-conductivity habitats was epiphytic on *Plectonema* in specific sites within our study area. *Keywords: Algae, Benthic flora, Invasive species.*

LOWES, C.I., DASSEY, T.W., and YOUNG, E.B., Dept Biological Sciences, University of Wisconsin Milwaukee, Milwaukee, WI, 53211. **Assessing Effects as Glyphosate as a Toxin and Potential P Source for Great Lakes Phytoplankton.**

Phosphorus (P) limits growth of Great Lakes phytoplankton. Most species readily use phosphate (Pi) and monophosphate esters. Recent research shows marine cyanobacteria can also use phosphonates, previously considered unavailable for phytoplankton. The phosphonate herbicide glyphosate is widely used in Great Lakes catchments. Phosphonate use by cyanobacteria and toxicity to algae was examined using growth trials. Cyanobacteria were grown with different P sources including glyphosate and its degradation product AMPA. Algae were provided with Pi and glyphosate or AMPA. Cell growth was monitored by chl fluorescence. Relative to growth rates with Pi, cyanobacterial strains grew at 16-50% with P-esters, and up to 38% with phosphonates. Both glyphosate and AMPA suppressed growth of eukaryotic algae. In bioassays with natural Lake Michigan water, phosphonate addition stimulated net phytoplankton growth. When cyanobacterial cultures supplied with glyphosate were inoculated with bacteria from Lake Michigan, they grew faster than without added bacteria, suggesting freshwater bacterial hydrolysis of phosphonates could release P for phytoplankton. Great Lakes cyanobacteria may use phosphonates as a P source and the toxicity to algae suggests glyphosate runoff may influence phytoplankton competition, promoting cyanobacteria.

Keywords: Cyanophyta, Phosphorus, Species diversity.

LOZANO, S.J.¹ and SCHAROLD, J.V.², ¹4840 S. State Rd., NOAA Great Lakes Environ. Res. Lab, Ann Arbor, MI, 48108; ²6201 Congdon Blvd., EPA MED-Duluth, Duluth, MN, 55804.
The Status of Benthos in Lake Ontario.

The benthic community of Lake Ontario was dominated by an amphipod (*Diporeia* spp.) prior to the 1990's. Two dreissenid mussel species *D. polymorpha* (zebra) and *D. bugensis* (quagga) were introduced in 1989 and 1991 via ballast water exchange. *D. bugensis* was observed as deep as 85 m in 1995, indicating the species ability to spread to deep, soft substrate habitats. As dreissenids became established, *Diporeia* dramatically decreased in abundance. *Diporeia* has disappeared in the shallowest zone (12-88 m) between 1994 and 2008. Recent surveys in 2003 and 2008 indicate that *Diporeia* are also disappearing in deeper areas of the lake (>90 m). The loss of *Diporeia* and the increase of *Dreissena* have implications on the trophic dynamics of the Lake Ontario benthic zone. *Keywords: Benthos, Diporeia, Dreissena.*

LUCENTE, J.E. and KELCH, D.O., One Government Center, Suite 550, Toledo, OH, 43604.
Utilizing Shipwrecks, Coastal Tourism and Maritime Heritage as an Economic Development and Water Resource Education and Outreach Tool.

Ohio Sea Grant created a comprehensive website and promotional guide designed to help Ohio residents and visitors locate and learn about the many historical, cultural and recreational shipwrecks in Ohio's Lake Erie waters, and to promote coastal tourism and business development. Both products will not only effectively serve to promote cultural and coastal tourism as tools to expand Lake Erie tourism revenues, but will also be valuable assets in the

conservation and protection of important shipwreck sites. Both the guide and the website highlight known, popular shipwrecks in four separate sectors of Ohio's Lake Erie shoreline: The Erie Islands Trailway, Vermilion-Lorain Trailway, Cleveland Trailway and Fairport Harbor Trailway. Promoting Ohio's rich maritime heritage established partnerships with the Ohio Department of Natural Resources Office of Coastal Management and eight coastal County Convention and Visitor Bureau's in developing and implementing plans to promote cultural and coastal tourism. In addition, Lake Erie's Coastal Ohio Program and the Lake Erie Circle Tour benefits through the establishment of linkages to the four designated underwater trailways.

Keywords: Conservation, Shipwrecks, Public education.

LUPI, F.¹, FENICHEL, E.P.², and HORAN, R.³, ¹Dept. of Agricultural, Food, and Resource Economics, Department of Fisheries and Wildlife, Michigan State University, East Lansing, MI, 48824-1039; ²School of Life Sciences, Arizona State University, Tempe, AZ, 85287; ³Dept. of Agricultural, Food, and Resource Economics, Michigan State University, East Lansing, MI, 48824-1039. **A Research Agenda for the Economics of Invasive Species in the Great Lakes.**

Invasive species management is both an ecological and economic problem. However, a recent assessment noted the severe dearth of information on the economic costs of invasive species (Colautti et al 2006). Others have noted problems with the quality of some economic studies (Hoagland & Jin, 2006). Recently, economists, ecologists and policymakers met to discuss economic research on aquatic invasive species in the Great Lakes. Participants agreed that an explicit economic research agenda could help transition from invasive species policies that react to established invasives toward proactive management that blends prevention, control, and adaptation. Consequently, we developed this agenda for research on the economics of invasive species in the Great Lakes. We identify key gaps in our economic knowledge of invasive species in the Great Lakes and illustrate how different types of economic research can inform invasive species management and policy making. Guidance is provided on how to evaluate existing or proposed economic studies. The research agenda identifies specific high priority economic research studies, data collection, modeling efforts, and other analyses that were identified and discussed at the workshop and in follow up efforts. *Keywords: Economic evaluation, Biological invasions, Economic impact.*

MA, J. and VENKATESH, S., 4905 Dufferin Street, Toronto, ON, M3H 5T4, Canada. **Multiple Pathways Modeling of Hexachlorobenzene to the Great Lakes from North American Sources.**

Hexachlorobenzene (HCB), or perchlorobenzene, is a chlorinated hydrocarbon with the molecular formula C₆Cl₆. It is a fungicide formerly used as a seed treatment, especially on wheat to control the fungal disease bunt. It has been also used in the production of chlorinated chemicals and is a byproduct of incineration of municipal waste. HCB has been listed as one of Level I persistent toxic substances by the Great Lakes Binational Toxics Strategy (GLBTS) for immediate virtual elimination. In light of the increasing concerns on the impact of historical releases of HCB and long-range transport, a numerical study was proposed to investigate the multiple pathways and total loadings of HCB to the Great Lakes basin using an atmospheric

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

transport model for organochlorine pesticides (OCPs) and emission inventories that have better geographical and temporal resolutions. This presentation will highlight preliminary results from this modeling study. *Keywords: Model studies, Pollution load, Great Lakes basin.*

MACDONALD, E. and TONTO, J.F., Pollution Probe, 625 Church Street, Suite 402, Toronto, ON, M4Y 2G1. **The Ottawa-Gatineau Watershed Atlas.**

Watershed based decision-making in the Ottawa River watershed basin is currently hindered by the jurisdictional fragmentation of information. Along the Ottawa River, which marks the border between Ontario and Quebec, each province is moving towards watershed management without recognizing the inter-jurisdictional nature of the Ottawa-Gatineau region. In addition, public understanding and opportunities for engagement in water issues is limited. Providing community members with easy access to water-related data along with contextual information would allow the public to share information, understanding, and responsibility for the management of their watershed. The Ottawa Gatineau Watershed Atlas Project (OGWA) project enables integration of watershed management on both sides of the Ottawa River in addition to providing a comprehensive public educational tool. The project takes an ecosystem approach using a watershed boundary rather than political boundaries bringing together collaborating partners, data, and information from both provinces. The project uses interactive geographic information system (GIS) and web technology to facilitate communication and data sharing between decision-makers and the public where communities can learn about their local watershed and contribute information and data for inclusion in the Atlas. *Keywords: GIS, Watersheds, Information sharing.*

MACKAY, M.D., Climate Research Division, 4905 Dufferin Str., Toronto, ON, M3H5T4, Canada. **Simulating Great Lakes Water Levels with the Canadian Regional Climate Model.**

Water levels in the Great Lakes show a large degree of variability due to natural climate variability, anthropogenic climate change, and/or direct human intervention. The attribution of lake level fluctuations to specific causes is not straightforward, though recent record low levels in Lakes Superior and Michigan-Huron have prompted some public outcry for immediate remedial action. Before any such action can be considered, it is essential to develop a deeper understanding of the water balance of the Great Lakes region historically, as well as plausible projections into the coming decades. Recently the International Joint Commission established a research programme – the International Upper Great Lakes Study – to address the question of changing lake levels and the possibility of modifying the existing regulation plan for Lake Superior outflow. Environment Canada is currently developing a *Great Lakes Regional Climate Modelling System* to support this study. This model is based on the well established Canadian Regional Climate Model coupled with the latest version of the Canadian Land Surface Scheme, a lake level – river routing scheme, and a thermodynamic lake model. Results for a ten year simulation of current climate will be presented. *Keywords: Model studies, Climate change, Hydrologic cycle.*

MAITRE, M.¹, FUNG, S.¹, DANIELS, C.¹, LIN, L.¹, and LAW, P.², ¹17250 Yonge St., Newmarket, ON, L3Y 6Z1; ²300-72 Victoria St. S., Kitchener, ON, N2G 4Y9. **The Consumptive Use Conundrum: Calculating Future Consumptive Use Related to Intra-basin Transfer in York Region.**

The Regional Municipality of York (York Region) conducted a series of calculations to determine consumptive use volumes associated with a proposed Intra-basin Transfer of Lake Ontario-based drinking water into the Lake Huron watershed. In the absence of a clear format with supporting parameters for completing this calculation, design guidelines, historical data, and assumptions based on literature review were utilized. Based on the variability of the parameters used in the calculations, sensitivity analysis was conducted on key parameters including evaporation rates, residential outdoor water use rates, distribution losses and leakage rates, and inflow/infiltration (I/I) rates. Findings indicated that the calculation was greatly affected by some parameters. *Keywords: Assessments, Consumptive Use, Drinking water, Lake Ontario, Lake Huron.*

MAKAREWICZ, J.C.¹, LEWIS, T.W.¹, PENNUTO, C.M.², BOYER, G.L.³, and EDWARDS, W.J.⁴, ¹125 Lennon Hall, The College at Brockport, Brockport, NY, 14420; ²Buffalo State College, Buffalo, NY; ³SUNY Environmental Science and Forestry, Syracuse, NY; ⁴Niagara University, Buffalo, NY. **Nearshore Nutrient Chemistry of Lake Ontario.**

Intensive monitoring using fixed stations and towed sensor arrays described the nearshore to offshore gradient during seasonal surveys at three sites within the coastal zone of Lake Ontario. The coastal sampling polygons (20 km x 5 km) were located adjacent to drainage areas dominated by the following land use patterns: urban, agricultural and undeveloped land. This presentation will focus on the gradient from nearshore to offshore in regards to phosphorus, nitrate, suspended solids and other tracers of watershed input. *Keywords: Coastal processes, Lake Ontario, Nutrients.*

MANNING, N.F.¹, MAYER, C.M.¹, BOSSENBROEK, J.M.¹, BRIDGEMAN, T.B.¹, and TYSON, J.², ¹University of Toledo Lake Erie Center, 6200 Bayshore Rd., Oregon, OH, 43618; ²Ohio Department of Natural Resources, 305 E. Shoreline Dr., Sandusky, OH, 44870. **Effects of Environmental Variables on Year 0 Yellow Perch Growth Abundance in the Western Basin of Lake Erie.**

Yellow perch (*Perca flavescens*) is an important species in Lake Erie for both economic and ecological reasons. We examined the role of several environmental parameters on the abundance and growth of age-0 yellow perch. Fish data were obtained from August trawls (Ohio DNR) between 1969 and 2004, and water quality data were from Ohio DNR and the Lake Erie Center's Maumee Bay monitoring program. We visualized potential relationships between environmental parameters and age-0 yellow perch abundance and length using kriging and co-kriging methods in ArcGIS. These relationships were used to create full models incorporating all potentially significant factors and interactions in the form of: $x = f(A+B+C+\dots)$ where x is abundance or length of age-0 yellow perch and A, B, and C are ecologically important factors, or

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

combinations of factors. Best-fit models, found using step-wise regression and AIC, showed that length and abundance are both influenced by turbidity, bottom oxygen levels, bottom temperature and depth, however, the direction of the relationships were opposite for the length and abundance models. Abundance was positively related to turbidity and depth, and negatively related to bottom oxygen and temperature, while length was the reverse of this.

Keywords: Yellow perch, Turbidity, GIS.

MANNY, B.A.¹, KENNEDY, G.W.¹, BOASE, J.², and KRUTSCH, D.³, ¹Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, MI, 48105; ²U.S. Fish and Wildlife Service, Alpena Fisheries Resource Office, Alpena, MI, 49707; ³Landmark Engineers, Inc., 2280 Ambassador, Windsor, ON, N9C 4E4. **Construction of Fish Spawning Habitat in the Detroit River.**

Fish habitat originally present in the Detroit River has been destroyed over the past 100 years by urbanization of the shoreline, filling of coastal wetlands, creation of deep-draft shipping channels, and disposal of dredge spoils. To restore fish spawning habitat in the Detroit River, we created 1,080 sq. meters of rock-rubble and coal cinders on the river bottom in 2004 in Michigan waters near Belle Isle and 3,300 sq. meters of rock-rubble on the river bottom in 2008 in Ontario waters near Fighting Island. Each of these projects was a collaborative venture funded by multiple sources at a cost of more than \$200,000. Pre-construction assessment revealed no fish spawned at Belle Isle and only 2 fish species spawned on sub-optimal substrates at Fighting Island. Post-construction assessment showed 16 fish species quickly spawned at Belle Isle, including 14 native and 2 exotic species. Results of these two projects has shown that fish spawning habitat can be restored successfully in this degraded, urban river to enhance populations of migratory lake whitefish and walleye that support sport and commercial fisheries downstream in Lake Erie valued at more than \$2 billion annually. *Keywords: Remediation, Habitats, Fish.*

MAREK, R.F.¹, THORNE, P.S.¹, NORSTROM, A.K.², and HORNBUCKLE, K.C.¹, ¹The University of Iowa, Iowa City, IA, 52242; ²Stockholm University, Stockholm, Sweden. **A Comparison of Blood PCB Concentrations in Industrial and Rural Communities: East Chicago, IL and Columbus Junction, IA.**

On the southwestern edge of Lake Michigan sits East Chicago, a heavily-industrialized community. Bisecting the area is the Indiana Harbor and Ship Canal (IHSC), which is known to be contaminated with PCBs and which flows near to residential areas and schools. Although the fate of these IHSC PCBs in relation to human exposure is still unclear, we hypothesize that residents of East Chicago have elevated levels of PCBs in their blood. In contrast, demographically-similar residents of the rural Columbus Junction, Iowa have no known PCB exposure from current or past industrial sources. Due to this difference in exposure, we also hypothesize that the PCB patterns between the two sample populations may be different. We have analyzed blood from children and their mothers in East Chicago and Columbus Junction for all 209 PCBs as part of an ongoing project through the Iowa Superfund Basic Research Program called the AESOP Study (Airborne Exposures to Semi-volatile Organic Pollutants). We present

our methods for sample collection and the preliminary results of blood analysis.

Keywords: PCBs, Human health, Urban areas.

MARENTETTE, J.R.¹, GOODERHAM, K.L.¹, HYNES, H.², MCMASTER, M.E.³, PARROTT, J.L.³, SLATER, G.F.², STOSIC, A.¹, WILSON, J.Y.⁴, and BALSHINE, S.¹, ¹Dept. of Psychology, Neuroscience and Behaviour, McMaster University, 1280 Main St. West, Hamilton, ON, L8S 4L8; ²Dept. of Geography and Earth Sciences, McMaster University, 1280 Main St. West, Hamilton, ON, L8S 4L8; ³National Water Research Institute, 867 Lakeshore Road, Burlington, ON, L7R 4A6; ⁴Dept. of Biology, McMaster University, 1280 Main St. West, Hamilton, ON, L8S 4L8. **Altered Behaviour and Physiology of Round Gobies (*Neogobius melanostomus*) Living in Contaminated Areas.**

Aquatic contaminants are a problem for both human health and ecosystem integrity. A recent invasive fish, the round goby, is ideal for examining the consequences of contaminant exposure because of its benthic nature, site fidelity and diet of zebra mussels. The incorporation of the goby into Great Lakes foodwebs means that contaminants previously restricted to zebra mussel biomass are increasingly available to higher order carnivores. We examined changes in behaviour and physiology of round gobies collected from highly contaminated and relatively clean areas of Hamilton Harbour, a Canadian IJC Area of Concern with a history of industrial and urban pollution. Contaminated areas had smaller, more female and more intersex fish than clean areas. Contaminated gobies showed decreased activity and aggression, greater fin loss, heavier PCB body burdens and elevated monooxygenase (e.g., EROD) activity compared to clean gobies. Contaminated gobies were also less likely to hide after a simulated predation event. Predictions of natural goby metapopulation dynamics in polluted waters will be affected by decreases in organism health, longevity and movement between areas. An impaired ability to evade predators in contaminated fish may also accelerate bioaccumulation of toxins in higher trophic levels, including humans. *Keywords: Round goby, Fish behavior, Fish toxins.*

MARKLEVITZ, S.A.C.¹, MORBEY, Y.E.¹, and FRYER, B.J.², ¹Department of Biology, University Of Western Ontario, London, ON; ²2. Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON. **The Use of Otolith Microchemistry as a Fisheries Management Tool: The Differentiation of Chinook Salmon, Natal Origins in Lake Huron.**

Chinook salmon were introduced to Lake Huron to control alewife and rainbow smelt populations and to increase the diversity of angling opportunities. The Great Lakes Fishery Commission has supported large scale Chinook salmon stocking programs since 1968, and the population now consists of wild stream-reared and hatchery-reared fish. The objective of our study was to differentiate Lake Huron Chinook salmon natal origin by examining otolith microchemistry. The biologically inert and archival properties of the otolith allow for the analysis of the environmental conditions throughout the life history of an individual fish. We examined Chinook salmon fry collected from 17 streams and 7 hatcheries around the Lake Huron region. A life history transect of the otoliths (core to edge) was analysed using Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry. Discriminant function analysis

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

indicated that differences in elemental composition are significant enough between sample sites to be used to assign natal origins. Our statistical model which can be used to assign (with some probability) natal origin of adult Chinook salmon caught in the main basins of Lake Huron. This powerful management tool could reduce the need for expensive and time consuming tag release studies. *Keywords: Fish tagging, Lake Huron, Salmon.*

MARSHALL, A.M.¹, STURTEVANT, R.A.², and RUTHERFORD, S.¹, ¹Eastern Michigan University, Ypsilanti, MI; ²NOAA Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108. **Great Lakes Data in the Classroom.**

It is important for students to use real data when investigating a question or problem. Inquiry requires students to use process skills such as analysis, synthesis, and evaluation. Unlike a cookbook lab, real data does not always produce a smooth curve on a graph, therefore students can practice many process skills by graphing and analyzing real data. There are many sites on the internet that provide data but this is often in a form that only a knowledgeable scientist can use. We describe the elements scientists should consider in efforts to make their data more accessible and tools and partners who can assist in this type of educational outreach. *Keywords: Education, Data storage and retrieval, Outreach.*

MARSHALL, A.M.², STURTEVANT, R.A.¹, and RUTHERFORD, S.¹, ¹Eastern Michigan University, 205 Strong Hall, Ypsilanti, MI, 48197; ²NOAA Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108. **Making GLERL Data Accessible to Teachers for Classroom Use.**

Dr. Sandra Rutherford, associate professor at Eastern Michigan University, received a NOAA sponsored Ocean Literacy Grant for the purpose of expanding the amount of ocean and Great Lake science taught in elementary classrooms by improving teachers' understanding and improving the methods of teaching of ocean science. There is also a secondary purpose of producing a teacher-friendly web resources that makes Great Lakes data from GLERL accessible for use by elementary teachers. My summer fellowship at GLERL required me to find three sets of raw data and put it in a format that could be utilized by teachers in a classroom. The three data sets I used were the CTD Data from the International Field Years on Lake Erie (IFYLE) to graph water column profiles of dissolved oxygen, temperature, fluorescence, and secchi depth; GPS Surface current data in Lake Michigan for each season. Surface currents were analyzed with other parameters such as: wind speed, wind direction, and the bathymetry of the lake; a storm surge and seiche event that measured wind speed/gust, wind direction, wave height/period, barometric pressure, and water levels at both the Western Erie basin and the Eastern Erie basin. A summer fellow will come up with three data sets each summer for four years so there will be at least twelve data sets by 2011. *Keywords: Education, Outreach, Data storage and retrieval.*

MARTIN, P.J.¹, THOMPSON, P.², KINKEAD, J.³, BELLAMY, S.R.¹, and VAN VLIET, D.J.¹, ¹AquaResource Inc., Breslau, ON; ²Ministry of Natural Resources, Peterborough; ³J. Kinkead

Consulting Inc., Mississauga. Development of a Methodology for Calculating Consumptive Water Use within the Province of Ontario.

Through the Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement, the Great Lake States and Provinces have committed to protect, conserve and restore the waters of the Basin. As part of the Agreement, parties have committed to further enhance the reporting of consumptive use information, and to regionally evaluate proposals with large consumptive demands. Consumptive use is defined as the portion of water withdrawn that is lost or otherwise not returned to the Basin, and has historically been estimated through use of generalized coefficients applied to the total volume of water withdrawn. To increase the reliability of consumptive use estimates, the Ontario Ministry of Natural Resources identified a need to refine consumptive coefficients and to develop a standardized process to enable accurate calculations. To fulfill this need, we have completed a literature review of consumptive use coefficients, developed a methodology for determining consumptive use for individual permit applicants, and developed a next-steps strategy. The results of this study will be presented, specifically a recommended tiered framework for estimating consumptive demand, which over time, will increase the accuracy of consumptive use estimates. *Keywords: Watersheds, Water use, Great Lakes basin, Consumptive demand, Hydrologic budget, Permits.*

MARTINEZ, A., HU, D., and HORNBUCKLE, K.C., Department of Civil and Environmental Engineering, The University of Iowa, Iowa City, IA, 52242. Fate of PCB Congeners in an Industrial Harbor of Lake Michigan.

The International Joint Commission has designated the Indiana Harbor and Ship Canal (IHSC) as an Area of Concern. A gradient flux model to estimate the fluxes and the emissions of PCBs from sediment to water and from water to air was developed for this system. Results show that the net emission from the air/water interface and the sediment/water are 9800 and 10,500 g yr⁻¹, respectively. The model assumptions include a constant gas transfer velocity for CO₂, estimated monthly air concentrations of PCBs, fixed water and sediment PCB concentrations during the year, and meteorological data obtained from Calumet Harbor, IL, station (NOAA). These results strongly suggest that IHSC is an important source of PCBs into Lake Michigan and into the surrounding atmosphere. However, no sensitivity analysis of the model has been carried out, which we think is relevant due to the many assumptions and constants that are used in the construction of the model. *Keywords: PCBs, Urban areas, Flux Model.*

MARTYNOV, A., SUSHAMA, L., and LAPRISE, R., UQAM@Ouranos, 550 Sherbrooke West, West Tower, 19th floor, Montreal, QC, H4W2B9, Canada. Coupling of the Canadian Regional Climate Model (CRCM) with 1D Lake Models: Application to the Great Lakes.

Implementation of interactive lakes in the CRCM is important to better simulate the climate system of North America, where lakes are abundant. The choice of lake models for coupling depends on different factors. The 1D lake models, treating lakes as adjacent horizontally homogeneous water columns and neglecting all horizontal fluxes, are convenient for coupling, relatively simple and require minimum information on lakes and are therefore used in

many climate models. The off-line tests of two widely used 1D lake models were carried out, showing good performance in small and shallow lakes. However, the model performances for large and deep lakes in off-line and preliminary coupled simulations (i.e. CRCM with interactive 1D lakes) were less satisfactory. Although the 1D lake models will remain a choice for the small and generally shallow subgrid lakes, more improvements are required for the large and deep freezing lakes. Using more advanced 1D lake models it may be possible to improve the simulations, but issues, related to the three-dimensional character of the Great Lakes physics, will remain. The corrections to the physical parameterization of the 1D lake models, based on empirical considerations or on numerical experiments, using the 3D lake model simulations of the Great Lakes, can be useful. *Keywords: Lake model, Climatology, Model testing.*

MARUTHI SRIDHAR, B.B.¹ and VINCENT, R.K.², ¹Department of Geology, Bowling Green State University, Bowling Green, OH, 43403; ²Department of Geology, Bowling Green State University, Bowling Green, OH, 43403. **Spectral Reflectance Measurements of a *Microcystis* Bloom.**

The objective of this study was to measure the in situ spectral reflectance of lake water that contains a bloom of *Microcystis*, a species of cyanobacteria. Reflectance spectra (350-2500 nm) of lake water near a boat dock in Upper Klamath Lake, Oregon, were collected with a portable spectroradiometer on a cloud-free day with sunlight as a source of illumination between 0845 to 0915 hours, Pacific Daylight Time (PDT) on August 17, 2004, at a near-normal angle of observation. The spectra showed reflectance maxima from 550-590 nm and near 710 nm wavelengths and reflectance minima near 630 nm and 675 nm wavelengths. The reflectance gradually decreases from 810-1000 nm and has very low reflectance in the 1000-2500 nm wavelength regions. These spectral results have implications in selecting the spectral ratios and refining the algorithms that will be used to estimate phycocyanin content using satellite models. *Microcystis* is the predominant species of cyanobacteria blooms in Lake Erie, which makes this spectral data as important to the Great Lakes as it is to Upper Klamath Lake. *Keywords: Remote sensing, Satellite technology, Harmful algal blooms.*

MASSON, C., Great Lakes Branch, Ontario Ministry of Natural Resources, Peterborough, ON, K9J 8M5. **The Great Lakes Gordian Knot II: Governance and Accountability for Aquatic Ecosystem Health, Integrity and Risk Management.**

How should we organise our agreements, policies, legislation and regulations to assign responsibility, manage risks, implement and evaluate accountability for aquatic ecosystem integrity? This analysis addresses three binational initiatives: the 1987 Protocol to the Great Lakes Water Quality Agreement of 1978; The Joint Strategic Plan for Management of Great Lakes Fisheries, 1997; and the Great Lakes-St Lawrence River Basin Sustainable Water Resources Agreement and eight-State Compact, 2005. It provides insight into the organizational landscape of large lake governance, with an emphasis on ecosystem-based planning, research and management. The study identifies similarities, differences, strengths and insufficiencies of each agreement, and probes for evidence of a shared vision, clearly defined roles and identifiable levels of risk. Areas of inquiry include: What problems is the agreement supposed to solve? Are

specific substantive rules established? What are signatories' behavioural obligations? Are cooperative activities enhanced? What are the relevant and available indicators of effectiveness? Is it timely? Is uncertainty reduced? Are there distinctions between what the agreement wants to accomplish and what it actually does? Unequivocal accountability for implementation may sever this Great Lakes Gordian Knot of governance. *Keywords: Strategic Great Lakes Fishery Management Plan, Great Lakes Water Quality Agreement, Sustainable Water Resources Agreement/Compact.*

MASTITSKY, S.E.¹, KARATAYEV, A.Y.¹, BURLAKOVA, L.E.¹, and MOLLOY, D.P.²,
¹Great Lakes Center, Science Building 261, Buffalo State College, 1300 Elmwood Ave., Buffalo, NY, 14222; ²Field Research Laboratory, Division of Research & Collections, New York State Museum, 51 Fish Hatchery Road, Cambridge, NY, 12816. **Freshwater Invertebrate Invaders as Vectors of the Spread of Parasites.**

Aquatic non-indigenous species (NIS) may serve as vectors of the spread of parasites, including highly pathogenic ones, from their donor areas. In addition, native parasites in recipient areas can switch from their native hosts to NIS, especially when NIS become dominant in invaded communities. Changes in parasitic systems caused by introductions of NIS and their specific parasites may result in serious epizootics that can negatively impact not only the biodiversity but also the economy of an invaded region. To study the ecological consequences of these introductions, we assembled a database on parasites of 22 freshwater invertebrate invaders, including 9 gastropods, 5 bivalves, 4 decapods and 4 amphipods. We found that each introduced host species may carry on average 1.8 ± 0.4 parasites which represent $21.6 \pm 5.9\%$ of all known parasites in the native area. Only 0.3 ± 0.1 parasite species ($2.7 \pm 1.3\%$ of all parasites in the native range) are classified as highly pathogenic for wildlife and/or humans. In addition, each introduced NIS became a host for on average 5.8 ± 1.7 parasite species native to the recipient areas, including 0.2 ± 0.1 highly pathogenic species. Our data support the need for concern about the parasitic interactions related to NIS introduction. *Keywords: Invasive species, Risks, Biodiversity.*

MATHIAS, P.T., BOSSENBROEK, J.M., HEPPNER, E.A., and CRAIL, T.D., The University of Toledo Lake Erie Center, 6200 Bayshore Rd, Oregon, OH, 43618. **Distribution of Unionid Mussels in the Ottawa River of Lucas County Ohio.**

Unionid mussels are one the most endangered temperate freshwater fauna with over 70% of the species listed as endangered. The Ottawa River in Toledo, Ohio has had many improvements and there are future plans for additional improvements within the University of Toledo's Main Campus. These improvements and plans have not taken into consideration the mussel fauna. We surveyed 68 sites along the Ottawa River to quantify the different environmental characteristics of this river corridor. We measured bank slope, width, benthic substrate, depth, flow, and stream type. At 18 randomly chosen sites, we determined the richness and abundance of unionids, which entailed looking for unionid mussels in a 40m segment of the stream. No relationships were found between species richness and width, flow, substrate size, depth, stream type, and bank slope. This study has established a baseline population estimate of

unionids in a selected part of the Ottawa River and has determined there is a random distribution of unionids within this urban stream. *Keywords: Unionids, Urban areas, Distribution patterns.*

MAYER, A.S.¹, BALLARD, M.M.¹, GRIFFIS, V.W.¹, GYAWALI, R.¹, MO, W.¹, WATKINS JR., D.W.¹, ZHANG, Q.¹, ZIMMERMAN, J.B.², and SATCHELL, E.¹, ¹Department of Civil & Environmental Engineering, Michigan Technological University, Houghton, MI, 49931; ²Environmental Engineering Program, Yale University, New Haven, CT. **Update on Modeling and Analyzing the Use, Efficiency, Value, and Governance of Water in the Great Lakes Region through an Integrated Approach.**

The objective of this project is to determine, through integrated physical and economic models and under various scenarios of population growth, climate change, land use, and emissions, the impact of direct and indirect drivers on water quality, quantity, and availability in the Great Lakes region. The project will emphasize quantifying the stocks and flows of fresh water, analyzing the underlying factors affecting water use and allocation decisions, and developing cost frameworks for capturing the value of having a specific amount of water available at a given purity, time, and location. This project will result in several advances in the analysis of water management issues, including (1) development of new, physically-based modeling approaches to simulate quantity and quality in the Great Lakes region; (2) creation and testing new, empirical models of the energy embodied in water delivery and treatment for the Great Lakes context; and (3) selection of relevant future climate, population, land use, and emissions scenarios to use as input to water quantity and quality predictions and in analyses of uncertainty in those predictions. We will report on recent progress, including the development of watershed models, water quality models, water treatment cost and energy models, and water demand models. *Keywords: Watersheds, Regional analysis, Hydrologic cycle.*

MCCAMMON, A.J., The Taylor Massey Project, c/o Ste 1606 - 39 Old Mill Road, Toronto, ON, M8X 1G6, Canada. **Reach by Reach : Ontario's First Community-led Watershed Regeneration Plan.**

Toronto's Taylor Massey Creek is the most polluted and degraded tributary to Ontario's dirtiest watercourse, the Don River. While many agency initiatives are being pursued, a community organization called the Taylor Massey Project has developed its own regeneration plan, Reach by Reach. Founded on a detailed current conditions report and a vision for the future of the watercourse with measurable goals, the plan contains suggestions for improved agency performance on watershed management. Its main innovation, however, is a call to regenerate each degraded reach of the creek in a comprehensive, prioritized, and phased manner. Reach by Reach contains cost estimates for its top five priorities, totaling \$4.275M, to regenerate 4 reaches of the creek, add 1% to the forest cover of the watershed, add 5 kilometers of both pedestrian and biking trail, and create two community stewardship groups over a five-year period, although proposed re-forestation efforts will take 20 years. The plan will be vetted through a series of community meetings in early 2009. *Keywords: Urban watersheds, Management, Remediation, Community.*

MCCARTHY, F.M.G.¹, MCANDREWS, J.H.², LEWIS, C.F.M.³, and BLASCO, S.M.³, ¹Earth Sciences, Brock University, St. Catharines, ON, L2S 3A1; ²Ecology & Evolutionary Biology and Geology, University of Toronto, Toronto, ON, M5S 3B2; ³Geological Survey of Canada, Natural Resources Canada, Bedford Institute of Oceanography, Box 1006, Dartmouth, NS, B2Y 4A2.

Explaining the Early Holocene Late Lake Hough Lowstand.

Multiproxy evidence of aridity correlates with lowstands in the Laurentian Great Lakes during the early Holocene, when orbital parameters resulted in greater seasonality. The resulting higher evaporation and evapotranspiration produced a deficit in effective moisture in the Georgian Bay basin that is recorded by the jack/red pine pollen zone. The moisture deficit reconstructed by the pollen-climate transfer functions is not sufficient to explain the late Lake Hough lowstand, however. A hydrologic model eliminating inflow from Lake Superior (via the St. Marys River) allows for closure of Lake Lake Hough. The resulting hydrologic deficit allowed water levels to fall ~5 m below that of Lake Stanley in the Huron basin, and, combined with the greater relative contribution of saline groundwater, produced brackish bottom waters recorded by a centropxyid thecamoebian-dominated fauna throughout the Georgian Bay basin ~8200 years ago. The more intense aridity in the Superior basin, recorded by prairie expansion into Minnesota, thus controlled lake levels throughout the Great Lakes Basin. We are investigating the relationship of this arid interval with the 8.2 k event and with Milankovitch parameters and sunspot activity. *Keywords: Climate change, Georgian Bay, St. Marys River.*

MCCARTHY, L.H., LAURSEN, A., BOSTAN, I.V., GILBRIDE, K., MARSHALL, G., and PEARCE, C., Depart. Chemistry and Biology, Ryerson University, Toronto, ON, M5B 2K3.

Protecting Canada's Drinking Water: Developing Real-Time, Early-Warning Biomonitoring Technology.

We are developing an early-warning system in real-time for drinking-water facilities that would detect chemical contaminants and pathogens using biomonitoring organisms. Natural bodies of water that ultimately constitute some of Canada's drinking water supply can contain a variety of pollutants such as heavy metals, PAHs, halogenated organic molecules, pharmaceuticals, and pathogens. While the associated health risks of some of these components are already known, there remains an alarming lack of research in many other areas. We are developing a holistic, multi-organism-based system to measure stress reactions in the aquatic community and are monitoring these stress responses in real-time. We will also develop ecotoxicity models based on dose-responses of individual organisms to specific classes of stressors (chemical and biological). These models will aid in the interpretation of the data and will provide information for water-utilities managers about the nature of the stressor. Our study currently is/will: 1) measuring responses in aquatic plants and invertebrates to chemical stressors at environmentally-relevant concentrations, and to pathogens; and 2) developing a microarray-based test that can be used to directly detect pathogenic organisms. *Keywords: Biomonitoring, Drinking water, Environmental contaminants.*

MCCULLOUGH, G.K.¹, STANTON, M.P.², KLING, H.J.³, and BARBER, D.G.¹, ¹Centre for Earth Observation Science, Department of Geography, University of Manitoba, Winnipeg, MB, R3T 2N2; ²Canada Department of Fisheries and Oceans, Freshwater Institute, 501 University Crescent, Winnipeg, MB, R3T 2N6; ³Algal Taxonomy and Ecology Inc., 31 Laval Drive, Winnipeg, MB, R3T 2X8. **Discrimination of Cyanobacteria in a Highly Eutrophic Great Lake, Lake Winnipeg, Manitoba, Canada.**

In recent years, severe cyanobacteria blooms have become of increasing concern to both users and managers of Lake Winnipeg, in central Canada. However, until these surface blooms develop in late summer, productivity is determined by the more desirable bacillariophyte and cryptophytes-dominated communities. We have used ship-borne remote sensing reflectance spectra paired with water quality data to test MERIS fluorescence line height (FLH) for monitoring these communities. While FLH explains 75% of variance in chlorophyll, this success is not due to the expected fluorescence peak at 685. Rather, over cyanobacteria, FLH records a local minimum in reflectance due to phycoerythrin absorption near 675 nm and “red edge” reflectance near 700 nm. Over other algae, FLH increases with increasing chlorophyll as expected. This different response between the two plankton communities limits the success of FLH as a global predictor of chlorophyll. However, it is also key to a procedure for discriminating cyanobacteria from other plankton. In this study, we show that a multiple band ratio algorithm (MERIS spectral bands) explains 63% of the variance of cyanobacteria biomass expressed as a fraction of total biomass, and predicts the cyanobacteria fraction with a standard error of 0.15. *Keywords: Remote sensing, MERIS, Cyanophyta, Phytoplankton.*

MCDONALD, C.P., URBAN, N.R., and CASEY, C.M., Department of Civil and Environmental Engineering, Michigan Technological University, Houghton, MI, 49931, United States. **Kinetic Modeling of the Nitrogen Cycle in Lake Superior.**

Increasing nitrate concentrations in Lake Superior are well-documented (Bennett 1986, Sterner et al. 2007) Recent studies suggest that atmospheric deposition alone cannot account for the observed increases in nitrate concentrations, and that biological transformation of reduced forms of nitrogen may be responsible (Finlay et al. 2007). Quantifying the rate at which this biological cycle operates is requisite to understanding the N cycle in the lake as well as other biologically-mediated processes (e.g., C cycling, residence time of toxic substances). While direct measurements of N uptake rates have been made (Kumar et al. 2008), the rates at which mineralization and excretion occur remain unknown. We have compiled a historical record of N inputs, and developed a mechanistic model to estimate the rates of biological processes associated with N cycling in the lake. The model was used to explore the response of the lake to reductions in N loading. Results indicate that despite the long hydraulic residence time, this large lake can respond to changes in loadings on the timescale of a decade because of the magnitude of the internal biological pump. The model also helps to constrain the magnitude of primary production in the lake to be at the upper end of the range reported in the literature. *Keywords: Nutrients, Lake Superior, Biogeochemistry.*

MCDONALD, E.A.¹, MCNAUGHT, A.S.¹, and ROSEMAN, E.F.², ¹Department of Biology, Central Michigan University, Mount Pleasant, MI, 48859; ²USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105. **Assessing Larval Fish Habitat Quality within the Detroit River.**

Habitat loss in the Detroit River caused a marked decrease in fish species between 1920 and 1980. Recent investigations of fish habitat use revealed renewed spawning activity by several important fishes; however little is known about the early life history requirements in this system. We surveyed two nursery and two main channel areas in the lower river weekly between May and July 2007 and examined larval growth, diet, and extent of habitat use. Larval fish were sampled with light traps in nursery areas and a bongo net in the main channel. Nursery areas had distinct macrophyte assemblages and substrate but similar temperatures. Larval fish diversity was highest in the main channel. Yellow perch and bluegill were common in the soft-sediment nursery, whereas round gobies and common shiners dominated the hard-sediment nursery. Emerald shiners and gizzard shad dominated the main channel. Fish species caught in main channel and nursery areas exhibited similar growth rates, but different age distributions. Only early stage larvae were present in the main channel, whereas early and late stage larvae were present in nursery areas. These data indicate that nursery areas are distinct from the main channel and are conducive to the development of certain larval species. *Keywords: Habitats, Fish populations, Detroit River.*

MCGRATH, K.J.¹, AULT, S.², and LAFRANCE, P.³, ¹New York Power Authority, 123 Main Street, White Plains, NY, 10601, US; ²Kleinschmidt, 2 East Main Street, Strasburg, PA, 17579, USA; ³Environnement Illimite, inc., 1453 Saint-Timothee, Montreal, QC, H2L 3N7, Canada. **Development of Lake Sturgeon Spawning Beds on the St. Lawrence River near Waddington, NY.**

Two artificial lake sturgeon (*Acipenser fulvescens*) spawning beds were built on the St. Lawrence River near Waddington, NY during the fall of 2007. Each bed is approximately 30 m wide and 30 m long; approximately 0.3 m thick; and consists of 5-10 cm crushed rock gravel. Approximately eight to 10 large boulders were deployed just downstream of each bed to serve as velocity breaks. The depth of water at each location varies from 9 to 12 m and current velocities range from 0.80 to 1.5 m/s. In spring 2008, sturgeon were consistently observed with underwater video cameras at both beds from May 10 (9°C) to June 13 (16°C). A distinct peak in sturgeon abundance was observed around June 9-10 when water temperatures reached 15°C. During the peak, approximately 115 sturgeon were observed on the two beds combined on one day of observation. Egg traps documented peak spawning on June 11-12 (15°C) and larval catch per unit effort peaked approximately two weeks later (June 24-26, 19°C). Previous studies in the area surrounding the spawning bed sites in 2004 and 2005 had shown no spawning activity or concentrations of sturgeon in the spring. Future plans are to continue to monitor the beds for sturgeon usage and to monitor the substrate for sedimentation/siltation and algal growth. *Keywords: St. Lawrence River, Lake sturgeon, Fish management, Acipenser fulvescens, Life history studies, Spawning bed.*

MCKINLEY, G.A.¹, BENNINGTON, V.¹, ATILLA, N.¹, URBAN, N.R.², WU, C.H.³, DESAI, A.¹, and KIMURA, N.⁴, ¹University of Wisconsin - Madison, Center for Climatic Research and Atmospheric and Oceanic Sciences, Madison, WI, 53706; ²Michigan Technological University, Civil and Environmental Engineering, Houghton, MI, 49931; ³University of Wisconsin - Madison, Civil and Environmental Engineering, Madison, WI, 53706; ⁴National United University, Taiwan, R.O.C. **The Magnitude and Mechanisms of the CO₂ Flux from Lake Superior.**

The Laurentian Great Lakes cover 25% of the land area of the 8 Great Lakes states, and seasonal CO₂ emissions from them may be comparable to local terrestrial ecosystems. Lake Superior is of particular interest because its fluxes directly influence nearby observations of the terrestrial carbon cycle. The ongoing CyCLeS (Cycling of Carbon in Lake Superior) project is working to quantify carbon fluxes from the Lake and to place them in the context of regional carbon budgeting efforts by the North American Carbon Program (NACP). As part of CyCLeS, we have configured a three-dimensional hydrodynamic model (MITgcm, Marshall et al. 1997) with an ecosystem-carbon module for the Lake. The model allows us to study the seasonal cycle of pCO₂ and the air-lake fluxes of CO₂ and to assess sensitivity to variable physical and biogeochemical forcings. We find that, without external inputs, the model is able to capture observations of pCO₂, net primary productivity (NPP), and other biogeochemical quantities within reasonable error estimates. This suggests that, for the long-term, lake-wide average, the Lake is not respiring significant amounts of terrestrial carbon, in contrast to findings by previous authors (Cole et al., 1994, Alin and Johnson, 2007). *Keywords: Carbon cycle, Atmosphere-lake interaction, Hydrodynamic model.*

MCKINNEY, T., Michigan Sea Grant, Ann Arbor, MI, US. **Strategies for Successfully Targeting and Collaborating with Underrepresented Groups.**

This session will guide research scientists, professors and outreach educators through strategies and methods to successfully target and collaborate with traditionally underrepresented groups by actively engaging K-12 teachers and students, undergraduate and graduate student populations from urban, rural and tribal communities and diverse backgrounds (i.e. gender, ethnic and cultural). The key components are: (1) increasing participation in science by underrepresented populations; (2) identifying minority educational organizations and associations with high minority participation; (3) providing recommendations for recruitment of underrepresented populations; and (4) targeting methods that help break down the invisible barriers to developing meaningful collaborations. In summary, this session will provide participants with opportunities for discussion; pose challenging questions and emerging solutions for collaborating with underrepresented populations in science.

MEGGO, R.E. and SCHNOOR, J.L., 4105 Seaman Centre, University of Iowa, Department of Civil and Environmental Engineering, Iowa City, IA, 52242. **Plant-Assisted Rhizosphere Mineralization of PCB Congeners.**

Sequential redox cycles of microbial dechlorination followed by aerobic biooxidation are desirable to achieve complete degradation of a mixture of higher and lower chlorinated PCBs. Research in our laboratory has shown that hybrid poplar trees are able to take up some lower chlorinated PCB congeners in hydroponic solution. This study investigates the potential for achieving complete mineralization and transformation of a mixture of PCBs by subjecting artificially contaminated soil planted with poplar to aerobic and anaerobic cycles through varying the moisture content. We hypothesize that this cyclic manipulation of redox conditions along with plant- microbial interactions in the rhizosphere will facilitate more complete degradation of PCB mixtures. *Keywords: Biotransformation, Environmental contaminants, Sediments.*

MERCADER, R.B. and DOBSON, T.A., Department of Fisheries and Wildlife, Michigan State University, 13 Natural Resources Bldg., East Lansing, MI, 48824-1222, USA. **Reducing AIS through Understanding the Human Dimensions of Live Baitfish Collection and Use.**

The commercial live baitfish industry undoubtedly contributes to the spread of aquatic invasive species and diseases within the Great Lakes Basin. To lower the risk associated with this vector, it is necessary to work with the entire supply chain from harvest to use by anglers in order to promote behaviors that limit the risk of transfer. Semi-structured interviews were conducted with managers and members of the baitfish industry in Michigan and Ontario, focusing on business practices, compliance with regulations, and attitudes towards policies. 5000 mail surveys were sent to licensed anglers in Ontario, investigating live baitfish usage, and attitudes towards policies, enforcement, and fisheries resources. The results of this research show that slowing the spread of aquatic invasive species and diseases through the live baitfish vector will require policies and outreach efforts at every step in the supply chain. Successful collaboration with the baitfish industry is necessary to the regulatory process, and voluntary training programs can help improve the performance of the industry. The likelihood of anglers disposing of their bait properly was found to depend on a number of factors, and survey results indicate that improvements must be made to public education and outreach in order to improve angler behavior. *Keywords: Invasive species, Public education, Environmental policy, Human dimensions.*

MERGLER, D., Université du Québec à Montréal, CP 8888, succ Centreville, Montréal, Qc, H3C 3P8. **An Update on Methylmercury Toxicity and Dietary Factors that Influence its Absorption, Metabolism and Toxicity.**

For humans, fish consumption is the major pathway for methylmercury exposure. Bioindicators of exposure (hair and blood mercury) vary with the frequency of consumption and the type of fish (high level predators have the greatest concentrations). Methylmercury exposure has been shown to be toxic for the developing fetus, children and adults. The nervous system is the prime target organ, but cardiovascular effects have also been reported and there is some evidence of reproductive and endocrine changes. Some studies suggest that there may be gender differences. Dietary factors may influence methylmercury absorption, metabolism and/or toxicity. In the Brazilian Amazon, it has been shown that, for the same mercury intake, bioindicators of exposure are lower among persons with higher fruit consumption compared to

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

those who eat less fruit. It has been suggested that selenium may influence mercury toxicity, but few studies have been performed with humans. Efforts to increase the benefits from fish consumption require a detailed knowledge of the hazards associated with exposure to mercury and other contaminants in order to adequately maximize the benefits and minimize the risks. Here, we will review the current evidence for methylmercury toxicity, with a particular emphasis on freshwater fish consumption. *Keywords: Environmental health, Fish diets, Methylmercury.*

MESSERVEY, R.W., Manager, Water Resources, Ontario Ministry of Natural Resources, Peterborough, ON. **Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement - Information and Science Provisions and Related Initiatives.**

Demonstrating their commitment to the Agreement, parties have worked diligently towards its implementation. On June 4, 2007, the Safeguarding and Sustaining Ontario's Waters Act received royal assent. The Act amended the Ontario's Water Resources Act to implement key requirements of the Agreement. Following their December, 2008 provincial election, Quebec will reintroduce implementing legislation to their National Assembly. The eight Great Lakes States ratified the Great Lakes-St. Lawrence River Basin Water Resources Compact, and the binding agreement came into force on December 8, 2008. Working towards the information and science provisions of the Agreement and Compact, parties have undertaken important regional initiatives. Through these initiatives, continued attention is devoted to understanding and adoption of Aboriginal Traditional Knowledge. In addition, science-based studies have synthesized and reported on consumptive use coefficients for the basin. Other studies have locally assessed groundwater and surface water supply, water budgets, and mapping. Information and products generated from these initiatives and others directly contribute to the information and science provisions of the Agreement, and to the greater scientific community. *Keywords: Hydrologic budget, Assessments, Water level.*

MICACCHION, M., Ohio EPA, DSW, Wetland Ecology Group, 4675 Homer Ohio Lane, Groveport, OH, 43125. **Evaluating the Amphibian Communities of Urban Wetlands using Level 1, 2 and 3 Wetland Assessment Tools.**

Of 200 randomly selected urban wetlands, 14 demonstrating appropriate habitat characteristics and five selectively chosen "reference" wetlands, all in central Ohio, were assessed to determine the quality of their amphibian communities. The wetlands were evaluated using Level 1, Landscape Development Intensity Index (LDI), Level 2, Ohio Rapid Assessment Method for Wetlands Version 5.0 (ORAM) and Level 3, both the Amphibian Index of Biotic Integrity (AmphIBI) and the Vegetation Index of Biotic Integrity (VIBI), wetland assessment tools. Monitoring results were compared between the urban and reference wetlands as well as with results from a large set of Ohio natural, individual mitigation and mitigation bank wetlands. Based on AmphIBI scores three of the urban wetlands were of "poor" quality, nine were of "fair" quality and two were of "good" quality and all reference wetlands were of "excellent" quality. Urban wetland AmphIBI scores compared most closely to scores for natural forest and shrub wetlands of poor quality and all natural emergent wetlands, however, were significantly different than scores of good and excellent quality natural forest and shrub and individual mitigation and

mitigation bank wetlands. The largest factor limiting amphibian community quality in urban wetlands was high intensity surrounding land uses. *Keywords: Amphibians, Wetlands, Urbanization.*

MIDA, J.L.¹, SCHAEFFER, J.S.², WARNER, D.M.², JUDE, D.J.¹, and SCAVIA, D.¹,
¹University of Michigan School of Natural Resources and Environment, Dana Building, 440 Church St., Ann Arbor, MI, 48109; ²USGS Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105. **Condition of the Opossum Shrimp (*Mysis relicta*) in Lakes Michigan and Huron, 2007: Preliminary Results of Lipid Analyses.**

Fish and zooplankton density and community composition and opossum shrimp (*Mysis relicta*) abundances differ significantly between lakes Michigan and Huron. This study seeks to investigate the role of *Mysis* in these food webs, with a focus on their availability and quality as a prey item for forage fishes. This goal will be met using three objectives, the first of which is to compare lipid content and fatty acid composition of *Mysis* in both lakes in order to understand their nutritional condition and value as food for fish. Lipid data for comparison will be obtained by determining total lipid content and fatty acid methyl ester (FAME) concentrations of samples of *Mysis* tissue collected from the study areas. The other two objectives, involving the exploration of predation on *Mysis* using fish diet studies, are not discussed in this paper. Preliminary lipid analysis results indicate that *Mysis* in Lake Huron on average have lower lipid levels than *Mysis* in Lake Michigan, and that in some areas of Huron *Mysis* may even be starving. This suggests that bottom-up influences on the lower food web may be more important than once thought. *Keywords: Food chains, Fish diets, Mysis relicta.*

MILEYEVA-BIEBESHEIMER, O. and GRUDEN, C.L., Department of Civil Engineering, The University of Toledo, Toledo, OH, 43606. **Impact of Metal Nanoparticles Found in Personal Care Products on Cell Viability.**

The number of consumer products incorporating nanoparticles is rapidly increasing, thus resulting in their disposition into the environment. The impact of metal nanoparticles on bacteria is not currently well-studied. Since bacteria play an important role in environmental processes, investigating the potentially negative effect of nanoparticles on bacteria is needed. In bench scale experiments, we studied the impact of titanium dioxide nanoparticles (0, 10, 50, 100, and 500 mg/L), commonly found in sunscreens and cosmetics, on bacterial viability. Fluorescent microscopy was used to determine bacterial quantity and viability following up to 6 hours of exposure in pure cultures and in complex samples. Data suggest that with increased concentration of nanoparticles, the percent of the non-viable cells increases (up to 86.7 %) when compared with the control samples (22.4%). Results of this experiment suggest a measurable impact on cell viability at concentrations between 10 and 100 mg/L following only 30 minutes of incubation. No significant difference in bacterial response to the nanoparticles was observed in the presence of natural organic matter. Ongoing experiments involve other metal nanoparticles and increasingly complex samples (wastewater). *Keywords: Metals, Nanoparticles, Cell viability.*

MILLER, C., MCELMURRY, S., and BRISTOL, C., Dept. of Civil and Environmental Engineering, Wayne State University, Detroit. **Real-time System Optimization for Sustainable Water Transmission and Distribution.**

This presentation provides the details of a project designed to promote the use of information technology to optimize system operation in water distribution systems to minimize energy consumption and improve environmental indicators. The project is of significance given the increasing energy requirements of modern water treatment and distribution systems. Energy consumption at water utilities represents one of the larger energy demands in most power systems. In the Great Lakes Basin, there are several very large water utilities that together represent a significant fraction of the regional energy consumption. For example, the DWSD water system serves over 4 million people in a very large geographic area in southeastern Michigan. Even incremental reductions in energy consumption would represent a significant benefit to the public in reduced emissions, operation costs, and peak-load demand for the power distribution network as a whole, increasing system reliability and reducing new plant construction. The ecosystem impact would be reflected in reduced greenhouse gas emissions and the associated environmental costs of ever-increasing energy use. In addition, as the energy requirements for utility operation are reduced, the use of alternative energy technologies (AET) in meeting system demand becomes more feasible. *Keywords: Regional service collaboration, Water utilities, Energy reduction.*

MILLIE, D.F.¹, WECKMAN, G.R.², FAHNENSTIEL, G.L.³, YOUNG, W.A.², DYBLE BRESSIE, J.⁴, and KLARER, D.M.⁵, ¹Florida Institute of Oceanography, University of South Florida, St. Petersburg, FL; ²Industrial & Manufacturing Systems Engineering, Ohio University, Athens, OH; ³Lake Michigan Field Station, Great Lakes Environmental Research Laboratory, National Oceanic & Atmospheric Administration, Muskegon, MI; ⁴Great Lakes Environmental Research Laboratory, National Oceanic & Atmospheric Administration, Ann Arbor, MI; ⁵Old Woman Creek National Estuarine Research Reserve, Ohio Department of Natural Resources, Huron, OH. **An ‘Enviro-Informatic’ Assessment of Saginaw Bay Phytoplankton: Data-Driven Discrimination and Modeling of *Microcystis* Abundance.**

Saginaw Bay, Lake Huron has a long history of anthropogenic perturbation; excessive nutrient loading and the establishment of non-indigenous dreissenid (zebra) mussels led to dramatic alterations in water quality and biogenic turbidity/production. Notably, annually-recurrent cyanobacterial blooms potentially influence utilization of aquatic resources and/or human-health. A previous NOAA study (1990-1996) provided comprehensive abiotic/biotic data concerning the impacts of mussel recruitment on the Bay’s water quality, and from which we identified - via non-linear modeling – the temporal and spatial dynamics of the Bay’s phytoplankton (as chlorophyll *a*). Using that same data set, here we explore diverse computationally-intensive, statistical approaches (e.g. non-metric multi-dimensional ordination, artificial neural networks, non-parametric multiplicative regression, etc.) to assess the compositional diversity and periodicity of phytoplankton biovolumes, with an emphasis on *Microcystis*. In addition to ‘pure’ description of the phytoplankton community, we are interested in enhancing the understanding of the Bay’s ecological complexity by identifying interactive

quantifiers, environmental and/or biotic forcing factors, and/or predictors for sentinel and/or problematic taxa. *Keywords: Harmful algal blooms, Phytoplankton, Lake Huron.*

MILLIGAN, M.S.¹, VALENTINE, L.¹, ORCHARD, A.¹, PAGANO, J.J.², HOLSEN, T.M.³, and HOPKE, P.K.⁴, ¹SUNY Fredonia, Department of Chemistry and Biochemistry, Fredonia, NY, 14063; ²SUNY Oswego, Environmental Research Center, Oswego, NY, 13126; ³Clarkson University, Department of Civil and Environmental Engineering, Potsdam, NY, 13699; ⁴Clarkson University, Department of Chemical Engineering, Potsdam, NY, 13699. **WHO Coplanar PCB, PCDD/F, and TEQ analyses in Great Lakes Fish.**

As part of the Great Lakes Fish Monitoring Program (GLFMP), we are analyzing whole fish composites collected at different sites from all five of the Great Lakes for a suite of contaminants such as Hg, PCBs, organochlorine pesticides, PBDEs, and PCDD/Fs. Five gram whole fish homogenates are extracted using Accelerated Solvent Extraction (ASE), followed by preliminary clean-up using automated gel permeation chromatography. After a multi-layer silica column clean-up step, the coplanar PCBs and PCDD/Fs are isolated using a dual-layer carbon column fractionation. The final extracts are then analyzed using gas chromatography/mass spectrometry. In this contribution, we will report on fish concentrations of the twelve coplanar PCBs designated by the World Health Organization (WHO), PCDD/F homologues, and 2,3,7,8-substituted PCDD/Fs. Using toxic equivalency factors for the twelve WHO-PCBs and the seventeen 2,3,7,8-substituted PCDD/F congeners, total TEQ concentrations will be calculated and compared for each lake. It has so far been observed that L. Michigan fish typically possess the highest concentrations of WHO coplanar PCBs, while L. Ontario fish have the highest concentrations of PCDD/F. For most samples, the largest contributor to the total TEQ is the WHO coplanar PCBs, primarily derived from the PCB-126 congener. *Keywords: Environmental contaminants, Fish toxins, PCBs.*

MILLS, E.L.¹, MUNAWAR, M.², and LUCKEY, F.³, ¹Cornell University Biological Field Station, 900 Shackelton Point Rd, Bridgeport, NY, 13030; ²Fisheries & Oceans Canada, 867 Lakeshore Rd, Burlington, ON, L7N 2S4; ³U.S. Environmental Protection Agency, 290 Broadway, 24th Floor, New York, NY, 10007. **Reality in a Fish Bowl and the Lake Ontario Ecosystem.**

Lake Ontario is the 17th largest lake in the world and provides a wide range of socio-economic services to over eleven million people in both Canada and the United States. In the 1970s, the implementation of two binational programs was successful at reversing eutrophication through reducing phosphorus loads and at restoring several native fish by controlling sea lamprey. Scientists continue to chase ecological change in the Lake Ontario ecosystem, and stressors associated with invasive species, watershed land use, and global climate change continue to challenge our understanding of the system. Current concerns include water quality degradation in coastal areas, the increasing occurrence of toxic algal blooms and viral outbreaks, the loss of the native benthic amphipod *Diporeia*, and exotic predatory zooplankton competing with forage fish for food. We review how new technologies, modeling, stakeholder involvement, and long-term ecological studies have been incorporated toward a comprehensive management

and monitoring plan for Lake Ontario. This plan includes an evaluation of the sensitivity of the lake ecosystem to multiple uses and services that will guide future management decisions.

Keywords: Lake Ontario, Monitoring, Stressors.

MINER, G.H. and BULLERJAHN, G.S., Department of Biological Sciences Bowling Green State University, Bowling Green, OH, 43402. **Utilization of Organic Phosphorus by Cyanobacteria.**

In freshwater systems, phosphorus (P) is often the primary factor limiting growth of autotrophs, like plants and algae. As an adaptive strategy to combat a deficiency in inorganic P, it is hypothesized that cyanobacteria have evolved mechanisms to utilize organic P sources like glyphosate (the active ingredient in the herbicide Roundup) and phosphonoacetic acid. I tested this hypothesis using the cyanobacterium *Synechococcus* ARC-21, exposing it in a factorial design to potassium phosphate (inorganic P), glyphosate, and phosphonoacetic acid. Growth of this cyanobacterium was significantly greater in the organic P additions (repeated measure ANOVA, and Tukey's HSD test, $\alpha=0.05$), compared to the inoculum with inorganic P. A second experiment was designed to determine if the algal community (with cyanobacteria) in Lake Erie could respond to additions of organic P. Water was obtained from the western basin of Lake Erie and was spiked with potassium phosphate, phosphonoacetic acid, and nothing respectively. Again, growth in the inorganic and organic P additions was significantly greater ($P < 0.05$) than growth in the control conditions. These results suggest that with increased use of glyphosate as an herbicide, the growth of potentially noxious cyanobacteria in Lake Erie may occur when there is an inorganic phosphorus deficiency. *Keywords: Lake Erie, Herbicides, Phosphorus.*

MOHAMED, M., HOWELL, E.T., and NETTLETON, P., Ontario Ministry of the Environment, Etobicoke, ON, M9P 3V6. **Interaction of Physical Processes and River Discharge on Nearshore Regions of Lake Huron.**

The development and application of methods to assess the interaction with adjacent shoreline and watersheds has been an ongoing aspect of the Ontario Ministry of the Environment Great Lakes Nearshore Monitoring Program. Recently, a field-based approach using arrays of water quality sensors has been developed to allow mapping of water quality features in coastal areas at high spatial resolution. The detailed point-in-time spatial representations of water quality, when supplemented with available geographic and more limited through-time water quality and physical information, provide strong insight on prevailing water quality and on the natural and anthropogenic factors affecting water over a study area. In 2003, a series of shoreline water quality surveys using this spatial mapping technique were conducted on the shores of Lake Huron adjacent to the mouths of three large rivers, the Saugeen, Maitland, and Bayfield Rivers, respectively. Additionally, a 3-dimensional hydrodynamic model was applied to examine the spatial and temporal dynamics in the Maitland River nearshore region over event episodes and the study period. In this work, we describe the complex conditions which exist in the nearshore region and demonstrate how conditions in this zone are intimately linked to the adjacent shoreline and watershed. *Keywords: Coastal processes, Ecosystem modeling, Spatial analysis.*

MOORHEAD, D.L.¹ and MILZ, S.², ¹Department of Environmental Sciences, 2801 W Bancroft St., MS-604, Toledo, OH, 43606-3390, United States; ²Department of Public Health and Homeland Security, 2801 W Bancroft St., MS-1028, Toledo, OH, 43606-3390, United States.
Ecological and Human Health: An Integrated Curriculum at the University of Toledo.

Human health is intimately connected to the quality of the environment. One of the important challenges faced by public health professionals is gaining sufficient breadth of training in both environmental sciences and human health to address these complex relationships. In general, the curricula of these programs seldom leave much opportunity for students to gain an adequate foundation in both fields. However, the environmental sciences curriculum design at the University of Toledo provides a foundation in environmental sciences, relevant interdisciplinary breadth in social sciences and humanities, and requires an area of concentration within a specific field of science. Thus a 3+2 program combining a BS in Environmental Sciences with a Master of Public Health was created. The key to the success of this program is a set of 4 graduate level courses that are completed during the senior year of the undergraduate program which also count towards the requirements of the graduate degree. The underlying rationale for this combined program is that public health is an important characteristic of the environment. *Keywords: Human health, Environmental health, Education.*

MOSS, M.R., Canadian Centre for Environmental Education, Royal Roads University, Victoria, BC, V8B 5Y2. **Post-Secondary Education and Environmental Professional Development in Canada; Certification, Accreditation and Life-long Learning.**

Outlined in this paper are some recent initiatives which relate to both the higher education sector and to the identification of an environmental profession in Canada. One set of developments, undertaken by the Environmental Careers Organization (ECO Canada) and its related body, the Canadian Environmental Certification Approvals Board (CECAB), certifies environmental practitioners (CCEP) based on national occupational standards (NOS). Over much of the same period the higher education sector has seen the establishment of several environmentally-focused program councils, both discipline-based and, more importantly, interdisciplinary-based. Examples of the latter are the Canadian Universities Environmental Science Network (CUESN) and the Canadian College Environmental Network (CCEN). Credibility to the career-related value of such programs is provided by a national program accreditation process administered by CECAB. In order to provide the professional with upgrading and updating, and as an entry point into the profession, the Canadian Centre for Environmental Education (CCEE) was established in 2006 as a partnership between ECO Canada and Royal Roads University to deliver a series of post-graduate, on-line programs based on curricula structured to address the national occupational standards (NOS).
Keywords: Environmental education, Professional certification, Program accreditation.

MUIR, D.C.G.¹, TEIXEIRA, C.¹, ENGBERS, H.¹, WANG, X.¹, BACKUS, S.², and KURT, P.³,
¹Environment Canada, Aquatic Ecosystem Protection Research Division, Burlington, ON, L7R 4A6; ²Environment Canada, Water Quality Monitoring and Surveillance, Burlington, ON, L7R

4A6; ³Environment Canada, Air Quality Research Division, Egbert, ON, L0L 1N0.

Atmospheric Deposition and Bioaccumulation of Current Use Pesticides and Selected Brominated Compounds in Ontario Remote Lakes in Ontario and the Great Lakes.

The objective of this study was to determine the deposition, concentrations in surface waters, and bioaccumulation of a wide range of current use pesticides (CUPs) and brominated organic compounds (BOCs) in remote lakes within the Great Lakes basin and in the open Great Lakes. CUPs were determined in large volume samples of surface and subsurface waters from 10 small inland lakes collected in 2003, '04 and '05 and in surface waters of Lakes Huron, Erie and Ontario sampled in summers of '06, '07 and '08. Precipitation samples were collected at 5 inland locations from April the end of August. Zooplankton (>100 µm) and phytoplankton (~1-100 µm) were collected at 3 inland lakes and in the Great Lakes. Of the 45 target CUPs about 60% were detected in lake water and 71% in precipitation. Major compounds in lake water and precipitation were ametryn, atrazine, desethyl atrazine (DEA), chlorothalonil, chlorpyrifos, dacthal, dyfonate, diazinon, endosulfan, metolachlor, metribuzin, and trifluralin. PBDEs were present in lake water at low pg/L concentrations. A low detection frequency of CUPs was found in zooplankton, compared to other media. However, the results demonstrate that some CUPs and BOCs are bioaccumulating following entry into the lakes via gas exchange and precipitation.

Keywords: Bioaccumulation, Pesticides, Organic compounds.

MUIRHEAD, J.R., Centre for Mathematical Biology, University of Alberta, Edmonton, AB, T69 2E9. **Forecasting Dispersal and Establishment of the Invasive Crustacean, *Cercopagis pengoi* Among Inland New York Lakes.**

Prediction of range expansion of nonindigenous species is important, and may be used as a first step in risk assessment and management. A combination of models for propagule pressure and habitat matching based on lake chemistry allows for refined predictions of where species may be expected to disperse and establish. Here, I model dispersal and habitat suitability for the invasive cladoceran, *Cercopagis*, among New York lakes. I surveyed recreationalists regarding the movement of trailered boats to model vector traffic among lakes, and used this measure of propagule pressure as the first input into a model assuming a negative binomial trip distribution. Within this model, I will assess the importance of several measures of attractivity that may draw recreationalists to particular lakes including the economic cost of transport. In turn, forecast trips among lakes will be combined with measures of water chemistry in a logistic model framework to assess the relative importance of each to *Cercopagis* invasions. Simulations will be highlighted that illustrate predicted differences in spread based upon dispersal vectors and environmental tolerances. *Keywords: Invasive species, Cercopagis pengoi, Distribution patterns.*

MUNAWAR, M.¹, FITZPATRICK, M.¹, NIBLOCK, H.¹, KLING, H.J.², and MUNAWAR, I.F.³, ¹Fisheries & Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; ²Algal Taxonomy & Ecology, Winnipeg, MB; ³Plankton Canada, Burlington, ON. **Comparing the Taxonomic Composition of Phytoplankton Determined by Fluoroprobe with Standard Microscopic Analysis in Hamilton Harbour, Lake Ontario.**

An attempt is made to assess the validity of FluoroProbe results consisting of chlorophyll a and spectral analyses of algal classes against the standard taxonomic data generated by the Utermöhl inverted microscope technique. A diurnal survey (at 0800; 1200 and 1600 h) was conducted on August 19, 2008 during the period of thermal stratification using multiple techniques to assess phytoplankton and primary productivity. Microscopic analysis indicated that epilimnetic phytoplankton assemblages were dominated by species of Dinophyceae (*Ceratium furcoides*, *Peridinium polonicum*) in the morning and noon samples (60% total biomass) while Chlorophyta species were more prevalent in the afternoon (40%). The FluoroProbe, however, presented an entirely different picture by classifying 50% of the epilimnetic biomass in the morning as “diatoms”. In the noon and afternoon samples, the FluoroProbe classified “greens”, “bluegreens” and “diatoms” as each contributing 30% to the total biomass. Our preliminary findings suggests that ground-truthing the FluoroProbe against standard taxonomic analysis is essential for realistic assessments of algal biomass and composition. DFO has conducted additional surveys using FluoroProbe on a lakewide basis in Lake Ontario. These surveys will be useful for further evaluation of the instrument. *Keywords: Algae, Monitoring, Measuring instruments.*

MUNAWAR, M.¹, FITZPATRICK, M.¹, NIBLOCK, H.¹, and KLING, H.J.², ¹Fisheries & Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; ²Algal Taxonomy & Ecology, Winnipeg, MB. **Evaluating the Planktonic Food Web of a Highly Stressed Area of Concern: Hamilton Harbour, Lake Ontario.**

Hamilton Harbour is a highly stressed embayment of Lake Ontario that has been identified for remediation under the Great Lakes Water Quality Agreement. As part of remediation efforts, Fisheries & Oceans Canada began a temporally extensive research and monitoring program in 2002 which is still in progress. This study offers a structural and functional assessment of the planktonic food web including bacteria, autotrophic picoplankton, phytoplankton, heterotrophic nanoflagellates, ciliates and zooplankton. We also consider size fractionated primary productivity and bacterial growth rates. Our results show that zooplankton accounted for approximately 50% of the biomass of the planktonic food web. However, when expressed as organic carbon, phytoplankton was the dominant component. The linkages between the various components of the planktonic food web will be discussed in detail with emphasis on energy transfer and assessing the overall health of the ecosystem. *Keywords: Eutrophication, Remediation, Carbon.*

MUNAWAR, M., NIBLOCK, H., and FITZPATRICK, M., Fisheries & Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Exploring Long Term Changes in the Planktonic Food Web of the Upper Bay of Quinte in Response to the Impacts of Phosphorus Abatement and Exotic Species.**

Phosphorus abatement was implemented in the Bay of Quinte beginning in 1978 as one of the remedial actions for the control of eutrophication. Long term data of TP indicated a steady decrease in concentrations supported by the reduction of chlorophyll a and phytoplankton

biomass. Beginning in 2000, the study of the entire microbial food web was included in the ongoing monitoring of the bay. This permitted the assessment of the complete planktonic food web and carbon budget including all components from bacteria to zooplankton. Our results show a change in the structure of the planktonic food web from being primarily heterotrophic to being primarily autotrophic. This change occurred suddenly beginning in 2005 with the onset of algal blooms. These blooms have been dominated by species of Cyanophyta including *Anabaena spiroides*, *A. circinalis*, *A. planctonica* and *Lyngbya limnetica* and composed up to 50% of the total planktonic biomass. Our results indicate that these structural changes will have implications for food web dynamics, fisheries and overall health of the Bay of Quinte. *Keywords: Ecosystem health, Algae, Eutrophication.*

MURPHY, S.C.¹, COLLINS, N.C.¹, and DOKA, S.E.², ¹University of Toronto at Mississauga, 3359 Mississauga Rd. N, Mississauga, ON, L5L1C6; ²Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **YOY Growth and Mortality for Warm and Coolwater Fish Residing in Small Coastal Embayments of Lake Ontario.**

Along the Lake Ontario shoreline near Toronto, Ontario, a large number of small coastal embayments have been constructed to provide recreational opportunities and restore warm and coolwater fish habitat. We expected the end-of-season size for warmwater fish in these embayments to be smaller than reported in inland lakes, since the beginning of their thermally defined growing season is delayed by the influx of cold Lake Ontario waters. In fall, the pumpkinseeds in our embayments are among the smallest reported in inland lakes with a size range of 12 - 40 mm (T.L). Based on comparisons of fall size distributions of YOY with size distributions of one-year-olds surviving the winter, we estimate that pumpkinseeds experience size-dependent overwinter mortality exceeding 60%, with those smaller than 27 mm rarely surviving. Interestingly, the YOY growth of warmwater largemouth bass is much less seriously limited than growth of pumpkinseed. Growth patterns of coolwater yellow perch in these embayments will also be covered in this presentation. *Keywords: Coastal wetlands, Lake Ontario, Fish.*

MWANGLI, J.M.¹, URBAN, N.R.¹, PERLINGER, J.A.¹, BARITEAU, L.², and FAIRALL, C.W.³, ¹Michigan Technological University, 1400 Townsend Drive, Houghton, MI, 49931; ²Cooperative Institute for Research in Environmental Sciences, 216 University of Colorado Boulder, Boulder, CO, 80309; ³Physical Science Division, NOAA Earth System Research Laboratory, 325 Broadway, Boulder, CO, 80305. **Eddy Covariance Measurements of CO₂ Fluxes above Lake Superior.**

Lake Superior has been reported to be seasonally supersaturated with respect to atmospheric CO₂, and fluxes estimated from measured *p*CO₂ are regionally significant. An empirical gas exchange model predicted that the CO₂ flux out of the lake is 0.1-0.4 g C m²d⁻¹ for an annual flux of ~140 g C m²d⁻¹. Nearby terrestrial fluxes are -8 to +4 g C m²d⁻¹, with an annual range of -120 to -300 g C m²d⁻¹. Eddy covariance measurements conducted in summer 2007 and 2008 at eight stations yielded 25 10-minute mean CO₂ fluxes in the range of -166 to +56 g C

m^2d^{-1} . The median flux among these values was $+3.4 \text{ g C m}^2\text{d}^{-1}$. Fluxes at near shore stations were larger and more variable than those further from shore. Statistical analysis of data resulted in a mean $\pm 95\%$ confidence interval of $2.1 + 5.6 \text{ g C m}^2\text{d}^{-1}$. Quality control of data, comparison with independent empirical estimates, and fluxes from other sites will be presented. These preliminary results suggest that short-term fluxes are much larger and more variable than previously estimated. The variability in space and time may make estimation of the lake-wide flux difficult. *Keywords: Lake Superior, Atmosphere-lake interaction, Carbon cycle.*

NADDAFI, R.¹, BLENCKNER, T.², EKLÖV, P.³, and PETTERSSON, K.², ¹Department of Natural Resources, Cornell University, 106 Rice Hall, Ithaca, NY, 14850; ²Department of Ecology and Evolution / Erken Laboratory, Uppsala University, Norr Malma 4200, Norrtälje, 76173, Sweden; ³Department of Ecology and Evolution / Limnology, Uppsala University, Husargatan 3, Box 573, Uppsala, 75123, Sweden. **Why is an Invasive Species More Successful in Some Areas than Others? A Comparison of Zebra Mussel Density in North American and European lakes.**

A major challenge in invasion ecology is to unravel fundamental questions such as which factors regulate invasion success and why some invaders become widespread and abundant in a novel environment. Zebra mussel (*Dreissena polymorpha*) is a successful invader with rapid growth rate that affects economy, community structure, and ecosystem function of lakes including Great lakes. An identification of the important factors that influence zebra mussel density can provide a basis for understanding the capacity for populations to expand and affect the ecology and economy of invaded aquatic ecosystems. We compared the density of the zebra mussel and the physicochemical data of ecosystems that it invaded among 14 North American and 55 European lakes. A Generalized Additive Model revealed that a joint effect of surface area, mean depth, total phosphorus and calcium concentrations explained more than 63 % of the variability in *Dreissena* density. Our study suggested that large, deep and less productive North American lakes can support larger local populations of zebra mussels. Our results highlight that the proliferation of an exotic species in an area can be explained with physicochemical properties of the recipient environment. *Keywords: Invasive species, Zebra mussels, Invasion success.*

NALEPA, T.F. and FANSLOW, D.L., 4840 S. State Rd., Ann Arbor, MI, 48108. **Recent Trends in Benthic Macroinvertebrate Populations in Lake Huron.**

We conducted a macroinvertebrate survey throughout the main basin of Lake Huron as part of a larger monitoring effort throughout the lake in 2007. The 85 sites sampled were generally the same as sampled in 2000 and 2003. In addition, we sampled 33 sites in Georgian Bay and North Channel that were also sampled in 2002. Major trends observed in the main basin in 2000-2003 continued in 2003-2007, the most dramatic of which were the continued decline of *Diporeia* and the increase in *Dreissena r. bugensis*. In 2007, mean densities of *Diporeia* were near zero at depths $< 30 \text{ m}$ and $31\text{-}50 \text{ m}$, and densities at sites $51\text{-}90 \text{ m}$ and $> 90 \text{ m}$ declined 81 % and 57 % since 2003. Mean densities were only 172 m^{-2} and 427 m^{-2} at the latter two depth intervals, respectively. In contrast, densities of *D. r. bugensis* increased at all four depth intervals

between 2003 and 2007. A maximum mean density of 2,392 m⁻² occurred at 31-50 m. *Dreissena polymorpha* was rarely found. The only other consistent trend in the main basin was the density of Oligocheata, which increased between 2000 and 2007 at < 30 m, but declined at 51-90 m and < 90 m. The decline of *Diporeia* in Lake Huron was similar to declines in Lakes Michigan and Ontario despite the presence of far fewer dreissenids. *Keywords: Benthos, Macroinvertebrates, Diporeia.*

NEDUNURI, K.V.¹, VINCENT, R.K.², ATKINSON, J.F.³, and SRITHARAN, S.I.¹, ¹Central State University, Wilberforce, OH, 45384; ²Bowling Green State University, Bowling Green, OH; ³Buffalo University, Buffalo, NY. **Causal Modeling of Growth of Cyanobacteria in Lake Erie for Phycocyanin Detection from LANDSAT TM Data.**

This paper presents an ongoing study of determining the effect of nutrient loading from the Maumee River, Ohio on the growth of *Microcystis* sp. algal blooms along the Maumee Bay shoreline of the southwestern basin of Lake Erie. The study by Vincent et al. (2004) enables the early prediction of algal blooms using LANDSAT TM imagery. In conjunction with the LANDSAT Mapping studies, we explore the effects of nutrient loading into the Lake and the hydrodynamic effects on the bloom propagation using a fate (kinetics) and transport model. Velocity and dispersion fields obtained from the hydrodynamic model suggested mixing of nutrients along the Maumee bay region which would concentrate these nutrients within this region and also facilitate settling. This may be one of the reasons for localized blooms along the Maumee bay region. Model predictions are in general agreement with the actual observations of phycocyanin concentrations of the blooms in the months of September 2000 and July 2001. Chlorophyll concentrations in the lake are sensitive to the maximum uptake rate of algal growth, phytoplankton respiration and mortality coefficients. The validated model using the study of Vincent et al (2004) can be used to identify practices in the watershed contributing to the nutrient enrichment. *Keywords: Lake Erie, Model studies, Eutrophication.*

NEKOUÉE, N.¹, ROBERTS, P.J.W.¹, SCHWAB, D.J.², and MCCORMICK, M.J.², ¹Civil Eng. Dep., Georgia Tech, 790 Atlantic Dr., Atlanta, GA, 30332; ²NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Rd, Ann Arbor, MI, 48108-9719. **3D Numerical Prediction of the Grand River Plume.**

Simulation of transport mechanisms and pollutant mixing in nearshore waters is of particular concern in lakes. For example, 3D numerical modeling has been widely applied to predict the behavior of point source pollutants such as river plumes. In this study, the Princeton Ocean Model (POM) is used to simulate the dispersion of the Grand River plume near local beaches with a grid size of 100 m in a 24 x 6 km domain. The open water boundary conditions are obtained from the whole Lake Michigan hydrodynamic simulations performed by GLERL with a 2 km grid resolution. The predictive capability of the model is increased by using a nested model (refining the grid size around the jetty). The hydrodynamic model has been integrated with a mass transport model to represent the nearshore tracer transport. The model predictions are compared with extensive field observations that include aerial photography, tracer release, drogue release, current meter moorings, meteorological stations, and 3D conductivity-

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temperature-depth profiling and bacterial sampling in the plume. Promising agreement has been observed between the field tracer concentrations and the model predictions. The results of this research will improve numerical modeling of nearshore water quality. *Keywords: Pollutants, Princeton ocean model, Lake Michigan.*

NELSON, H., PETERSON, K.A., and SPAULDING, B., Fluid Imaging Technologies, 65 Forest Falls Drive, Yarmouth, ME, 4096. **New Method to Detect and Identify Nuisance Cyanobacteria and Invasive Bivalves using a Continuous Imaging Particle Analyzer (FlowCAM).**

Monitoring water systems for nuisance Cyanobacteria and invasive Zebra and Quagga Mussels is an extremely important yet daunting task for the water quality professional. Interestingly, these two taxa each have very unique optical properties that differentiate them from other organisms. Cyanobacteria cells contain the pigment Phycocyanin, and when 'excited' by certain wavelengths of light, give off a very distinct emission. The shells of the Zebra and Quagga Mussels are calcareous, and when viewed with a cross-polarized light source, reflect the light from the calcite, emitting a unique pattern commonly referred to as the 'Maltese Cross' (a phenomena called Birefringence), even when viewed as veligers in their planktonic state. The imaging particle analyzer – FlowCAM - has been in use since 2000 by microbiologists to study plankton in marine and freshwater systems. The instrument utilizes a combination of light sources and filters (532 nm laser, Flash LED, two Emission Filters) to detect and image microscopic organisms and particles in a fluid stream. Once detected, organisms possessing these unique characteristics are imaged, and the unique optical parameter is measured and saved to help define the organism. An overview of the technology will be given, along with data from natural samples. *Keywords: Biological invasions, Algae, Zebra mussels.*

NETTESHEIM, T.G.¹, HITES, R.A.², VENIER, M.², PARK, R.³, BANIC, C.M.³, and BACKUS, S.⁴, ¹USEPA Great Lakes National Program Office, 77 West Jackson Boulevard, G-17J, Chicago, IL, 60604; ²The School of Public and Environmental Affairs – Indiana University, 1315 East Tenth Street, Bloomington, IN, 47405; ³Environment Canada, 4905 Dufferin Street, Toronto, ON, M3H 5T4; ⁴Environment Canada - Great Lakes Studies, 867 Lakeshore Rd., P.O. Box 5050, Burlington, ON, L7R 4A6. **Revisiting the Mauve Bible: Is the Atmosphere Still Significant?**

The last large effort to estimate the relative importance of atmospheric deposition to the Great Lakes in relation to other pathways occurred in the late 1980s and early 1990s culminating with the well-known "Mauve Bible" by Strachan and Eisenreich in 1992 and the First Great Waters Report to Congress in 1994. Since then, a litany of research and publications have greatly increased our understanding of atmospheric deposition. These efforts have in turn resulted in mass balances for individual lakes and/or chemicals. However, there has not been a concerted effort to revisit the early estimates of the relative importance of atmospheric deposition. This presentation will seek to answer the question: Is the atmosphere still significant?

Keywords: IADN, Toxic substances, Air-water interfaces.

NEVILLE, L.A., MCCARTHY, F.M.G., and TINKLER, K.J., Earth Sciences, Brock University, St. Catharines, ON, L2S 3A1. **Evidence of an Early Holocene Drought in the Lower Great Lakes?**

Paleoclimatic evidence indicates substantial oscillations of the Great Lakes water levels. Much evidence exists suggesting that the Upper Great Lakes experienced near drought conditions close to the 8200 BP event, such as the closed basin conditions in Georgian Bay during the late Lake Hough lowstand. Despite the abundance of paleoclimate studies published from the lower Great Lakes, they reveal little evidence of aridity during the early Holocene, perhaps through lack of resolution. Preliminary research however does suggest that the lower Great Lakes were affected by the global instability created during the 8200 year event, with wetlands small bodies of water such as Hamilton Harbour showing increased aridity and alkalinity. Paleoclimate evidence in wetland and lacustrine records is similar in characteristics and timeline to that established in the upper Great Lakes, but is more muted than in Georgian Bay. This is consistent with the interpretation that the closure of late Lake Hough reflected the much drier conditions in the Superior basin, and not the conditions surrounding Georgian Bay. The more subtle response to the 8200 year event in the Lower Great Lakes is being investigated, and sunspot activity may have been an important control on early Holocene climates in this region. *Keywords: Climate change, Lake Ontario, Lake Erie.*

NEWSTED, J.L.¹, NAILE, J.², JONES, P.D.², and GIESY, J.P.², ¹Entrix, Inc., 4295 Okemos Road, Suite 101, Okemos, MI, 48864; ²Department of Biomedical and Veterinary Biosciences and Toxicology Center, University of Saskatchewan, Saskatoon, SK. **Toxicity of Perfluorooctane Sulfonate (PFOS) to Avian Wildlife: Ambient Safe Water Value Derivation and Uncertainty Analysis.**

Water quality values were derived using Great Lakes Initiative (GLI) methodology to evaluate the possible risks that perfluorooctane sulfonate (PFOS) may pose to avian wildlife. These toxicological benchmarks were based on data from studies conducted with bobwhite quail, mallards and chickens. Toxicological endpoints included mortality, growth, and histopathology. Reproductive endpoints included egg production, hatchability and survival and growth of offspring. Avian Wildlife Values (WV) were derived using bioaccumulation and biomagnification factors taken from laboratory and field studies to extrapolate threshold dietary and/or tissue PFOS concentrations to water concentrations for three avian species. Based on these data, safe water concentrations for bald eagle, kingfisher and herring gulls were 71, 36 and 41 ng PFOS/L, respectively. The avian wildlife value was determined to be 47 ng PFOS/L. A sensitivity analysis was conducted to examine the uncertainty associated with the bioaccumulation and dietary assumptions used in the extrapolation model. The results from this analysis indicated that the selection of bioaccumulation factors had the greatest impact on the derived wildlife values. Finally, these wildlife values are discussed relative to current freshwater PFOS concentrations measured in Great Lakes waters. *Keywords: Perfluorooctane sulfonate, Bioaccumulation, Water quality.*

NGHIEM, S.V.¹ and LESHKEVICH, G.A.^{2, 1}Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA, 91109; ²NOAA/Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108. **Validation of a Satellite Synthetic Aperture Radar (SAR) Ice Classification Algorithm.**

Ice cover in the Great Lakes has a major impact on commerce, public safety, and is a sensitive index of regional winter climate. Moreover, ice type has an impact on ice breaking operations and under ice ecology. The large spatial coverage and 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 ice types. Initial algorithm validation was performed in February 2008, when classified, color-coded RADARSAT-1 imagery was downloaded to the USCGC *Mackinaw* during icebreaking operations in Green Bay. Results show that with one exception, the algorithm correctly classified the ice types in the library that were found along the ship track, and will be described during the presentation. *Keywords: Remote sensing, Ice, Satellite technology.*

NIMS, M.K.¹, COLLINGSWORTH, P.D.¹, VAN TASSELL, J.J.¹, OLESIK, J.W.², and MARSCHALL, E.A.¹, ¹Aquatic Ecology Laboratory, The Ohio State University, 1314 Kinnear Road, Columbus, OH, 43212; ²The Ohio State University Trace Element Research Laboratory, 026 Mendenhall Laboratory, 125 South Oval Mall, Columbus, OH, 43210. **Determining When Otoliths of Larval Walleye Establish a Natal Site Signal.**

To use otolith microchemistry in determining natal origins of freshwater fish, we must understand when environmental trace elements leave their signatures in larval otoliths. This experiment was designed to determine whether larval walleye (*Sander vitreus*) otolith uptake rates are rapid enough to record a natal site signal. In April 2008, eggs from spawning walleye in the Maumee River, OH were fertilized and then incubated in water spiked with different concentrations of strontium. At hatch, larvae were transferred to tanks with an experimental design of two replicate tanks for each level of strontium (300, 900, and 1500 µg/L) crossed with two temperatures (8°C and 13°C). Egg samples were taken 2 and 4 days pre-hatch and the day of hatch. Larval samples were taken every other day, beginning with day of hatch, for 20 days. Otoliths were removed and processed using laser ablation and solution based inductively coupled plasma mass spectrometry. By 20 days post-hatch, larval otoliths showed a treatment-related strontium signal. Otolith Sr:Ca ratios from larvae reared in low and high elemental treatments were higher at both temperatures than otoliths from the control treatment. Our results indicate that otoliths can be used to determine natal origin if larvae were in separate environments for at least 20 days. *Keywords: Otolith, Fisheries, Walleye.*

NORRIS, K.D.¹, BERQUIST, M.², SZWEC, J.³, RIDAL, J.³, CAMPBELL, L.M.¹, and HODSON, P.V.¹, ¹Queen's University, Kingston, ON; ²Queen's University, Kingston, ON; ³St. Lawrence River Institute, Cornwall, ON. **Mercury in Lake St. Francis Walleye: The Role of Sources of Mercury Source, Bioavailability, and Food Chain Transfer.**

In 1985, Lake St. Francis, a lake on the St. Lawrence River, was identified by the International Joint Commission as part of an Area of Concern due to high concentrations of mercury in sediments and walleye. Tissue concentrations of mercury (Hg) in walleye in this area exceed Ontario's consumption guidelines with almost twice the concentration of Hg found in walleye upstream. The overall goal of this study is to identify the mechanisms and main sources that are contributing to the elevated Hg concentrations in walleye from Lake St. Francis. Our previous research showed that total Hg concentration in sediment is not a reliable predictor of total Hg in fish. However, there were significant correlations between the concentrations of methyl mercury (MeHg) in sediment pore water and concentrations in amphipods, as well as a significant correlation between Hg concentrations in amphipods and in perch. By examining the geographic pattern of elevated concentrations of Hg and MeHg in sediment pore water, amphipods, and yellow perch, we will identify the potential sources of Hg to Lake St. Francis. To more fully understand the pathways contributing to the bioaccumulation of Hg in walleye, the correlations among the concentrations of MeHg and Hg in sediment pore water, amphipods and yellow perch will be examined. *Keywords: Mercury, Methylmercury, St. Lawrence River.*

NORTON, R.K.¹, MEADOWS, L.A.², and MEADOWS, G.A.³, ¹University of Michigan, Urban & Regional Planning, 2000 Bonisteel Blvd., Ann Arbor, MI, 48109; ²University of Michigan, College of Engineering, 1221 Beal Ave., Ann Arbor, MI, 48109; ³University of Michigan, Naval Architecture & Marine Engineering, 1085 S. University Ave., Ann Arbor, MI, 48109. **Lake Level Dynamics and the Ordinary High Water Mark on Lake Michigan Shores: Implications for Shoreline Management Policy and Law.**

Great Lakes shorelines encompass dynamic physical systems, sensitive natural ecosystems, and valuable real estate. Ongoing shoreline development throughout the Great Lakes requires reconciling the vitality of these systems with private property rights, development needs, and the public interest. Doing so effectively into the future will require developing a better understanding of Great Lakes shoreline dynamics and using that knowledge to develop and implement effective and reasonable shoreline management policies and laws. Currently, shoreline development along Michigan's Great Lakes shorelines is managed through a combination of state and local plans, policies, and regulations. A key element of that system is the Ordinary High Water Mark—a concept developed originally in tidal ocean settings and transplanted to the Great Lakes. Limited work has been done to date to assess the effectiveness of current shoreline management efforts. This session will present findings from ongoing research that integrates analysis of the evolution of the nearshore bathymetric environment of the Lake Michigan coastline with analysis of state and local land use planning, policy, and regulation in selected Lake Michigan coastal jurisdictions, focusing on OHWM movement over time and corresponding implications for shoreline management policy and law. *Keywords: Shore protection, Coastal processes, Policy making.*

O'DONNELL, D.M.¹, QUARING, G.F.¹, STRAIT, C.M.¹, EFFLER, S.W.¹, and LESHKEVICH, G.A.², ¹Upstate Freshwater Institute, P.O. Box 506, Syracuse, NY, 13214; ²Great Lakes Environmental Research Laboratory, 2205 Commonwealth Blvd, Ann Arbor, MI, 48105.

Spectral Measurements of Absorption, Beam Attenuation and Backscattering Coefficients, and Remote Sensing Reflectance in Four Laurentian Great Lakes.

Spectral absorption, beam attenuation, and backscattering coefficients (a , c , and b_b) and the remote sensing reflectance (R_{rs}) were measured on Lake Ontario in mid-spring 2008 and on Lakes Michigan, Huron, Erie and Ontario during the first two weeks of August 2008. Measurements were made using a combined profiling package of ac-s and BB9 meters (WETLabs®). The ac-s measures a and c with a spectral resolution of 4 nm over the range 400 – 730 nm; spectral scattering (b) are obtained by difference, $c - a$. The BB9 measures b_b at nine wavelengths within the range of 400 – 715 nm. R_{rs} was measured with a HyperPro II (350 – 800 nm) (Satlantic®). Spectral and vertical patterns of a , c , b and b_b are reported. Comparisons of optical characteristics between the different lakes are presented including differences in b , the diffuse light attenuation coefficient and Deep Chlorophyll Layers. Measurements of R_{rs} are demonstrated to close well with MODIS imagery. We illustrate the applicability of a common marine optics model that describes the dependence of R_{rs} on b_b and a . *Keywords: Remote sensing, Inherent Optical Properties.*

O'MEARA, J.M.¹, CARLOCK, M.M.², and SIEDLACZEK, B.B.², ¹Environmental Consulting & Technology, Inc., 2200 Commonwealth Blvd., Suite 300, Ann Arbor, MI, 48105; ²City of Southfield, 26000 Evergreen Road, Southfield, MI, 48037-2055. **Resource Restoration with in an Urban Watershed: Carpenter Lake Restoration And Nature Preserve Development.**

The purpose of this project was to ecologically restore Carpenter Lake and develop an associated nature preserve. The lake is located in Southfield, Michigan within the Rouge River Watershed, which is considered to be the state's most urbanized watershed. The project incorporated innovative storm water techniques and improved public recreation and wildlife habitat. The existing dam, which was undersized and breeched, was reconstructed to prevent failure. The lake and dam restoration vastly improved conditions by removing invasive fish and aquatic species and creating lake structural and ecological habitat to foster increased wildlife/fish populations. Over 30,000 cubic yards of sediment was removed to re-shape and provide depth to the lake. Wetland fringe areas and structural habitat were created to provide habitat for native fish and wildlife. An invasive fish removal program was conducted within the lake and upstream river portion to help establish a better native/sport fish population. The lake's storm water controls will now also help control urban flood events which, in the past, had severely damaged downstream ecology. Additionally, a new 42-acre nature preserve with a trail system and interpretive signage was developed around the restored lake. *Keywords: Restoration, Urban watersheds, Ecosystems.*

OFFENBERG, J.H.¹, LEWANDOWSKI, M.¹, KLEINDIENST, T.E.¹, EDNEY, E.O.¹, JAOUI, M.², SHEESLEY, R.J.³, and SCHAUER, J.J.³, ¹National Exposure Research Laboratory, US Environmental Protection Agency, Research Triangle Park, NC, 27711; ²Alion Science and Technology, P.O. Box 12313, Research Triangle Park, NC, 27709; ³Environmental Chemistry and Technology Program, University of Wisconsin-Madison, Madison, WI, 53706.

Contributions of Primary and Secondary Organic Carbon to Ambient PM in Midwestern US Cities.

Ambient PM_{2.5} samples were collected in five midwestern United States cities throughout 2004: East St. Louis, IL; Detroit, MI; Cincinnati, OH; Bondville, IL; and Northbrook, IL. Monthly composites were analyzed using chemical derivatization coupled with GC-MS analysis to estimate the contributions of several sources to the total ambient organic carbon. A chemical mass balance (CMB) approach was used to estimate contributions from several primary sources. An additional, organic tracer-based technique was employed to estimate secondary contributions, including secondary organic carbon derived from isoprene, α -pinene, β -caryophyllene, and toluene. The sum of these contributions was compared with the total organic carbon measured at each sampling site, and reasonable carbon mass balances were observed for four of the five sites. In Bondville, Northbrook, Cincinnati, and Detroit a strong correlation was observed between the sum of the estimated primary and secondary contributions and the measured organic carbon ($R^2 = 0.73$). The estimated secondary organic carbon concentrations varied considerably with season, with the strongest contributions coming from isoprene and α -pinene during the summer. *Keywords: Organic carbon, Chemical analysis, Organic compounds.*

OLSON, W.J. and BOOTSMA, H.A., University of Wisconsin-Milwaukee GLWI, 2200 E. Kenwood Blvd., Milwaukee, WI, 53201. **An In-Depth Look into the Metabolic Dynamism of the Nearshore Region of a Great Lake.**

In this study, a moored buoy equipped to continuously measure high-frequency carbon dioxide and dissolved oxygen (DO) in the air and surface waters of Lake Michigan was used to estimate the net metabolism of the nearshore region across the 2008 summer stratification period. In addition to the continual monitoring of surface water CO₂ dynamics, this study incorporated vertical profiles which measured CO₂ and DO concentrations at multiple depths and habitats within the nearshore region throughout the year. Vertical profiles regularly conducted within a habitat representative of a *Cladophora* rich benthos inundated with the invasive quagga mussels were directly compared to vertical profiles obtained within a sand dominated community in order to evaluate the influence of dominant benthic composition on surface water CO₂ observations. This study has allowed us to compare diel metabolic signals across a region typical of the Lake Michigan shoreline and ultimately determine if the nearshore has acted as a net biological sink or source for atmospheric CO₂. Such measurements have also revealed how the balance between net productivity and respiration changes throughout the year in conjunction with nutrient and temperature fluctuations consequential of upwelling or storm events. *Keywords: Carbon cycle, Metabolism, Coastal ecosystems.*

ONI, S.K.¹, FUTTER, M.N.², and DILLON, P.J.³, ¹Environmental and Life Sciences, Trent University, Peterborough, ON, K9J 7B8, Canada; ²Macaulay Land Use Research Institute, Macaulay Drive, Aberdeen, AB15 8QH, Scotland; ³Environmental and Life Sciences, Trent University, Peterborough, ON, K9J 7B8, Canada. **Effect of Land Use Changes on Dissolved Organic Carbon Fluxes in Lake Simcoe Watershed.**

Lake Simcoe is a large (3557 km²) watershed in central Canada. The catchment is drained by seven main tributaries and numerous smaller input streams. Land cover in the watershed comprises a mixture of agriculture, forest and wetlands but with increasing urban pressures. We hypothesize that this increasing human development in Lake Simcoe catchment will provoke changes in land use, thereby altering dissolved organic carbon DOC export to the lake. Land use change enhances mineralization of soil carbon and modifies DOC fluxes to the aquatic systems. These changes will potentially impact the future of Lake Simcoe water resources as DOC impair water quality and influence other water quality parameters such as trace metal toxicity. However, less is known about the effect of land use changes on DOC fluxes in the environment. Here we report on the use of INCA-C (the Integrated Catchments model for Carbon) to simulate DOC dynamics in rivers in the Lake Simcoe watershed. This is the first in which INCA-C has been used in agricultural and urban catchments. Our results show that INCA-C can be applied to large, non-forest dominated catchments. Model results suggest that increasing modification of land use within the Lake Simcoe watershed has large quantitative impact on the carbon budget of Lake Simcoe. *Keywords: Dissolve organic matter, Lake Simcoe, Hydrodynamic model, Ecosystem modeling, Biogeochemistry, Carbon cycle.*

OZERSKY, T.¹, MALKIN, S.Y.¹, DEPEW, D.C.¹, HOUBEN, A.¹, BARTON, D.R.¹, and HECKY, R.E.², ¹University of Waterloo, 200 University Ave. W., Waterloo, ON, N2L 3G1; ²University of Minnesota, Duluth, 2205 East 5th Street, Duluth, MN, 55812. **Phosphorus Excretion by Dreissenid Mussels Can Meet *Cladophora* P Demand Along a Portion of Lake Ontario Shoreline.**

We report the results of a study designed to assess the importance of phosphorus excreted by dreissenid mussels to sustaining nuisance growth of the filamentous green algae *Cladophora glomerata* along a portion of Lake Ontario shoreline. A survey of dreissenid distribution and biomass was combined with the results of in situ phosphorus excretion experiments to determine the magnitude of bioavailable phosphorus contribution from dreissenid mussel beds in our study area. Dreissenid P excretion is compared with modeled P demand by *Cladophora* and with P inputs from the watershed. Results show that dreissenid mussels are capable of supplying P in excess to *Cladophora* demand and are excreting more P than is supplied by watershed sources in our urbanized study area. These results raise important questions about our ability to manage nuisance *Cladophora* growth using traditional P control strategies *Keywords: Dreissena, Lake Ontario, Cladophora.*

PADDOCK, R.¹, BASKARAN, M.², BIDDANDA, B.A.³, NOLD, S.⁴, RUBERG, S.⁵, and KLUMP, J.V.¹, ¹Great Lakes WATER Institute, University of Wisconsin-Milwaukee, Milwaukee, WI, 53204; ²Wayne State University, Detroit, MI; ³Annis Water Resource Center, Grand Valley State University, Muskegon, MI; ⁴University of Wisconsin-Stout, Stout, WI; ⁵NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI. **Sediment Accumulation Rates in the Middle Island Sinkhole, Thunder Bay National Marine Sanctuary, Lake Huron.**

As part of an interdisciplinary investigation of the biogeochemical processes active in a series of sublacustrine sinkholes recently discovered in Lake Huron, we have dated a 70 cm long sediment core recovered by divers in September 2008 from a sinkhole off Middle Island. The net permanent sediment accumulation rate was determined using Pb-210 and Cs-137 geochronologies. Excess Pb-210 was present throughout the entire length of the core. Surface activities were in excess of 35 dpm/g and decreased exponentially with depth. The sedimentation rate was estimated to be $\sim 300 \text{ mg cm}^{-2} \text{ yr}^{-1}$, a rate which is at least an order of magnitude higher than rates observed in the open profundal regions of the lake. These sinkholes are characterized by a high volume input of anoxic groundwaters emanating from the underlying carbonate rock, and containing high concentrations of dissolved nutrients, methane, radium isotopes, and other minerals. At the Middle Island sinkhole this submarine venting supports a unique photolithotrophic microbial community and extensive microbial mats. The accumulation and burial of organic carbon and nitrogen, as well as the carbon and nitrogen stable isotopic signatures of the sediments have also been determined. *Keywords: Biogeochemistry, Paleolimnology, Lake Huron.*

PANGLE, K.L.¹, BUNNELL, D.B.², REICHERT, J.³, DRELICH, A.¹, and LUDSIN, S.A.¹, ¹The Ohio State University, 1314 Kinnear Road, Columbus, OH, 43212; ²USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI; ³University of Windsor, 401 Sunset Ave, Windsor, ON, N9B 3P4. **Effects of Chemo-Physical Variation Associated with High Discharge Events on Yellow Perch Larval Habitat Quality in Western Lake Erie.**

Quality of fish habitat in open-water environments is generally dictated by chemo-physical properties of the water column (e.g., temperature, suspended sediments, nutrients). In western Lake Erie, as in other regions of the Great Lakes, these properties can vary spatially and temporally, owing to wind-driven circulation and inputs from tributaries. To better understand the influence of such habitat heterogeneity on fish populations, we developed a spatially-explicit model that predicts growth rate of larval yellow perch (*Perca flavescens*) as a function of chemo-physical factors and zooplankton densities. The model was parameterized using field information collected in western Lake Erie during spring 2006-2008 and validated using observed otolith-derived growth rates, with high correlation between observed and predicted growth rates. Model results indicate that larval growth rates in western Lake Erie can strongly vary at both fine and large temporal and spatial scales. This variation was most greatly driven by high discharge events out of the Maumee River. These findings provide insight into mechanisms that influence yellow perch recruitment in Lake Erie and demonstrate the need to consider variation in chemo-physical properties in the Great Lakes open-water environment and the phenomena that create such conditions. *Keywords: Yellow perch, Lake Erie, Computer models.*

PARROTT, J.L., MCMASTER, M.E., and TETREAULT, G.R., Environment Canada, 867 Lakeshore Rd, Burlington, ON, L7R 4A6. **Effects of Municipal Wastewater Effluents and Pharmaceuticals in Fish.**

Pharmaceuticals and personal care products have been detected at very low concentrations in municipal wastewater effluents (MWWs) and rivers in North America and

Europe. Some recent research suggests possible effects in fish exposed to some of these compounds. For example, fathead minnows exposed for a lifecycle to the synthetic estrogen used in birth control pills, ethinyl estradiol, showed fewer male characteristics and decreased ability to fertilize eggs. Effect concentrations were at or below 1 ng/l, a concentration which has been found in some MWWs. Real MWWs are complex mixtures of nutrients, oils, metals, with trace levels of some pharmaceuticals and personal care products. Exposure for a lifecycle to 100 % Ontario MWW reduced male sex characteristics and decreased egg production by over 50 %, even though female fish grew well and had large ovary sizes. Wild male fathead minnows captured from a creek in Saskatchewan that receives MWW had fewer sex characteristics and were smaller than reference male fish. More research is necessary to determine whether pharmaceuticals (or other compounds) in MWWs are affecting fish downstream.

Keywords: Fish, Environmental effects, Toxic substances.

PASCOE, T., WATSON, S.B., STRUGER, J., YERUBANDI, R., GUO, J., and GAGNON, L., Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Getting Our Feet Wet: Preliminary Data on Algal Blooms and Nutrients in Lake of the Woods, Year 1.**

Lake of the Woods (LOW) is a large extremely complex international water body which spans Minnesota, Manitoba, and Ontario. Water levels in this lake are regulated by four dams controlling inflow at the south end from the Rainy River, and outflow to the northern Winnipeg River. The total drainage area is ~55,600km². LOW consists of two regions with contrasting physical and chemical characteristics; a large mixed south basin, and a complex northern region consisting of numerous interconnected smaller sub-basins with different depths and mixing regimes. These sub-basins receive different hydrological and material inputs from both the South Basin and Canadian Shield drainage, resulting in N-S gradients of productivity and water chemistry which are logistically challenging to study. Recently, there have been growing concerns with the implications of severe, potentially toxic blooms of cyanobacteria, widely perceived to be increasing in frequency and distribution in LOW. Such blooms are usually driven by high nutrient levels; however despite a large database collected by US-Canadian partners, the sources, bioavailability and transport/sequestration of nutrients in LOW are not well understood. This poster presents an overview of the issues, the key goals of the initiative and preliminary data collected during year 1 of the study. *Keywords: Nutrients, Algae, Lake Winnipeg.*

PATTERSON, K., Partners for Clean Streams, PO Box 822, Bowling Green, OH, 43402. **Ecological and Human Health Risk Assessment for Duck and Otter Creeks.**

The aim of this project is to produce human health and ecological risk assessments for the Duck and Otter Creeks located in the City of Oregon, Ohio. These are two small streams that flow into the mouth of the Maumee River and have been severely impacted by industrial land uses. The Great Lakes Legacy Act provides funding to clean up contaminated sediments within U.S. Areas of Concern. To qualify for that funding, the U.S. EPA must be presented with risk assessments that make the case that contamination in Duck and Otter Creeks threaten both human and ecological health. The risk assessment project is intended to assist with leveraging

further funding from the Legacy Act and incidentally would support the Act by building the pipeline of actionable projects and demonstrating public demand for the funds available. The presentation will highlight the results of the project and the outcomes that will assist in the future directions towards possible Great Lakes Legacy funding opportunities for the local communities, partners and agencies within these watersheds. *Keywords: Watersheds, Ecosystems, Management.*

PATTERSON, R., University of Toledo; Sociology, Toledo, OH, 43606. **The Intersection of Africana Studies in Environmental Studies.**

The African American community has historically been estranged from the environmental movement. Since the 1990s, however, the environmental justice movement has emerged with a focus more attuned to the social justice orientation that is much more familiar and relevant with the black community. African Americans are far more likely to live around brownfields, hazardous waste sites and other locally unwanted land uses (LULUs). Remediation is more likely to occur when African Americans become both better informed and more engaged to correct infractions. Additionally, with the newly emerging green sector of Northwest Ohio, there is a need to get black and other minority populations better informed about new opportunities for employment and remuneration. Africana Studies, with its established academic and community service work in the black community, could play an indispensable role in preparing future participants in the environmental justice movement in the black community. My paper examines Africana Studies programs around the country to document the level of environmental engagement with the black community. The paper concludes with curricular and service learning recommendations. *Keywords: Remediation, Urban areas, Public participation.*

PAUER, J.J.¹, ANSTEAD, A.M.¹, MELLENDEZ, W.², and ROSSMANN, R.³, ¹Z-Tech, an ICF International Company, 9311 Groh Road, Grosse Ile, MI, 48138; ²CSC Corporation, 9311 Groh Road, Grosse Ile, MI, 48138; ³USEPA Large Lakes Research Station, 9311 Groh Road, Grosse Ile, MI, 48138. **SMALL SHOULD BE THE NEW BIG: High-Resolution Models with Small Segments have Big Advantages when Modeling Eutrophication in the Great Lakes.**

Historical mathematical models, especially Great Lakes eutrophication models, traditionally used coarse segmentation schemes and relatively simple hydrodynamics to represent system behavior. Although many modelers have claimed success using such models, these representations can introduce large inaccuracies in describing the system and making predictions. A high-resolution modeling framework improves estimates of phytoplankton concentrations in Lake Michigan. High-resolution frameworks are especially important when water temperatures, primary production and phytoplankton concentration gradients in the lake exist during spring. Frequent solar radiation estimates improve the calculation of light limitation and thus phytoplankton production and concentration in the lake. Using three-hour solar radiation estimates instead of daily averages, which are most commonly used in eutrophication models, improves the production estimate during mid-day when the sun inhibits algal growth at the lake's surface. The advantages of using this high-resolution model to describe eutrophication, as well as setting nutrient loading targets in the Great Lakes, will be discussed. This abstract does

not necessarily reflect EPA policy. *Keywords: Ecosystem modeling, Eutrophication, Hydrodynamics.*

PAVLAC, M.M.¹, SMITH, T.T.¹, THOMAS, S.P.¹, BOYER, G.L.¹, MAKAREWICZ, J.C.², LEWIS, T.W.², PENNUTO, C.M.³, BASILIKO, C.³, EDWARDS, W.J.⁴, and ATKINSON, J.F.⁵,
¹SUNY College of Environmental Science and Forestry, Syracuse, NY; ²SUNY Brockport, Brockport, NY; ³Buffalo State College, Buffalo, NY; ⁴Niagara University, Niagara University, NY; ⁵SUNY Buffalo, Buffalo, NY. **Application of Continuous Monitoring in the Lake Ontario Nearshore.**

The Lake Ontario Nearshore Nutrient Survey (LONNS) conducted in the summer of 2008 was designed to assess the effect of *Cladophora*, dreissenid mussels, and physical forces on the movement of nutrients entering the lake. As part of that survey, continuous real-time monitoring was employed in the nearshore areas of Oak Orchard, Rochester, and Mexico Bay in New York. The ferry box was equipped with sensors for chlorophyll, phycocyanin, CDOM, temperature, conductivity, turbidity, dissolved oxygen, and pH. Phytoplankton class abundance was estimated using the BBE FluoroProbe operated in continuous-flow mode. These data streams were geo-referenced and used to examine the spatial and temporal change of the different parameters relative to the riverine inputs. Initial results showing the variations in the distribution and composition of algal growth, as well as the physical data, will be presented. *Keywords: Phytoplankton, Lake Ontario, Monitoring.*

PEBBLES, V.I. and PEARSON, B.A., Great Lakes Commission, 2805 S. Industrial Hwy, Suite 100, ANn Arbor, MI, 48104-6791. **Great Lakes State and Provincial Smart Growth Trends.**

This paper describes land use and smart growth policy trends among the Great Lakes states and provinces. It begins with an overview of the environmental, social and economic impacts of unplanned land development, commonly referred to as sprawl. It highlights population growth projections compared to land consumption as an indicator of unsustainable land development. The balance of the paper describes the "smart growth" policies of the 10 states and provinces that surround the Great Lakes to address these unsustainable land development trends. The smart growth policies described are based on data and information collected between 2005 and 2007. *Keywords: Urbanization, Policy making, Management.*

PENAMON, W.A. and MENTZER, G.C., College of Education, The University of Toledo, Toledo, OH, 43606. **The Role of Mentoring in Promoting Positive Attitudes of Minority Students Towards STEM Careers.**

This research examines the role of the National Science Foundation (NSF) funded University of Toledo (UT) GK-12 mentoring program in promoting positive attitudes of minority high school students towards STEM (science, technology, engineering, mathematics) subjects and careers. An attitude survey developed for evaluation research by Online Evaluation Resource Library was selected to measure minority student participants' attitudes towards mathematics

and science; this evaluation instrument was specifically designed for under-represented populations and was created by evaluators in the course of their work on other NSF funded projects. The survey measured student attitudes toward mathematics and science in the domains of content, education, performance, practical value, profession, rigor, skills, and understanding; it used an ordinal scale ranging from SA (strongly agree) to SD (strongly disagree). This measure was also administered to an equivalent comparison group of high school minority students who were not participants in the UT GK-12 program. Survey results were analyzed using Rasch Modeling which transforms the ordinal data to an interval scale in order to perform statistical comparisons between groups. *Keywords: STEM careers, Minorities, Mentoring programs.*

PENNUTO, C.M.², JANIK, C.P.¹, FISCHER, A.¹, BASILIKO, C.², and MAKAREWICZ, J.C.³,
¹Biology Department, Buffalo State College, Buffalo, NY, 14222; ²Great Lakes Center, Buffalo State College, Buffalo, NY, 14222; ³Environmental Science and Biology, SUNY Brockport, Brockport, NY, 14220. ***Cladophora*, Gobies, and Mussels, Oh My: a LONNS Update on their Distribution and Abundance in Nearshore Lake Ontario.**

The recent resurgence of *Cladophora* mats in the Great Lakes, coupled with declining offshore nutrient levels, seems to provide support for a nearshore nutrient shunt. We determined the abundance and distribution of *Cladophora*, round gobies, and dreissenid mussels in the nearshore environment of Lake Ontario as part of the Lake Ontario Nearshore Nutrient Study (LONNS). These observations, coupled with data on lake hydrodynamics, tributary nutrient inputs, bathymetry, and water column nutrients, will allow creation of land-derived nutrient fate models. *Cladophora* mat biomass declined with depth and season and exhibited a slight decline from west to east. Mat biomass was not extremely high in summer 2008 relative to other summers or locations in the Great Lakes. Mean goby abundance declined in the nearshore with season and increased with depth late in the summer, but not spring when abundance either declined (central sample site) or was unaffected by depth (western sample site). Goby abundance showed no strong difference across the lake. Dreissenid mussels were exclusively *D. bugensis* at all depths and sites in the nearshore environment. Mussel density increased with depth and showed no difference across the lake, whereas mussel size increased with depth and exhibited a strong reduction in size traveling west to east. *Keywords: Cladophora, Invasive species, Nutrients.*

PEREZ-FUENTETAJA, A.¹, CLAPSADL, M.¹, MARKHAM, J.², and KAYLE, K.³, ¹Biology Dept. & Great Lakes Center, SUNY - Buffalo, Buffalo, NY, 14222; ²New York State Dept. Environmental Conservation, Lake Erie Unit, Dunkirk, NY, 14048; ³Ohio Dept. of Natural Resources, Division of Wildlife, Fairport Harbor, OH, 44077. ***Shiners and Smelt are the Main Forage Base for Steelhead Trout (*Oncorhynchus mykiss*) Populations in Lake Erie.***

Steelhead trout (*Oncorhynchus mykiss*) are the most numerous salmonine in Lake Erie. Stocking programs place approximately two million steelhead per year into the lake. Little is known about their diet and the demand they place into the lake's forage base. We used stomach content data collected from June-October (fish ranging from 350 mm–840 mm) and bioenergetics modeling to estimate the amount of prey consumed over the study period. Seventy

five percent of the diet was comprised by rainbow smelt (*Osmerus mordax*) and emerald shiners (*Notropis atherinoides*). Steelhead switched proportions of prey between shiners and smelt in mid-season, reflecting differences in prey availability. Total lakewide prey consumption during the study period was estimated at 4.9 kilotonnes (KT). We estimated steelhead consumption of rainbow smelt at 2.32 KT, emerald shiners at 1.46 KT, round gobies (*Apollonia melanostomus*) at 0.36 KT and other fish species at 0.46 KT. Invertebrates, mostly Bythotrephes and terrestrial insects represented 0.15 KT of the diet. Emerald shiners and rainbow smelt were the two main species supporting steelhead populations in Lake Erie during our study period. These estimates can be used for fisheries management based on assessment of the total demands placed upon the Lake Erie forage base by piscivorous fishes. *Keywords: Assessments, Bioenergetics, Fish diets.*

PERHAR, G. and ARHONDITSIS, G.B., Physical & Environmental Sciences, University of Toronto, Toronto, ON, M1C 1A4, Canada. **The Role of Highly Unsaturated Fatty Acids in Aquatic Food Webs.**

In planktonic food webs, the conversion rate of plant material to herbivore biomass is determined by a variety of factors, such as seston biochemical/elemental composition, phytoplankton cell morphology, and colony architecture. Despite the overwhelming heterogeneity characterizing the plant-animal interface, plankton population models usually misrepresent the food quality constraints imposed on zooplankton growth. In this study, we reformulate the zooplankton grazing term to include seston food quality effects on zooplankton assimilation efficiency and examine its ramifications on system stability. Using different phytoplankton parameterizations with regards to growth strategies, light requirements, sinking rates, and food quality, we examined the dynamics induced in planktonic systems under varying fish predation, light conditions, nutrient availability, and detritus food quality levels. In general, our analysis suggests that high food quality tends to stabilize the planktonic systems, whereas unforced oscillations (limit cycles) emerge with lower seston food quality. For a given phytoplankton specification and resource availability, the amplitude of the plankton oscillations is primarily modulated from predation and secondarily from the nutritional quality of the alternative food source (i.e. detritus). *Keywords: Ecosystem modeling, Phytoplankton, Zooplankton.*

PERKINS, M.G.¹, STRAIT, C.M.¹, EFFLER, S.W.¹, QUARING, G.F.¹, and LESHKEVICH, G.A.², ¹Upstate Freshwater Institute, PO Box 506, Syracuse, NY, 13214; ²Great Lakes Environmental Research Laboratory, 2205 Commonwealth Blvd, Ann Arbor, MI, 48105.

Characterization and Cross-Sectional Analysis of Absorbing Components in Five Great Lakes.

Light absorbing constituents are important regulators of the signal available to assess water quality from remote sensing. The magnitudes and spectral features of absorbing components, including colored dissolved organic matter (CDOM or gelbstoff; a_{CDOM}), phytoplankton (a_{phyto}), and non-algal particles (NAP; a_{NAP}) were determined for near-surface waters at multiple sites in Lake Erie (2008), Lake Michigan (2008), Lake Huron (2008), Lake Ontario (2008) and Lake Superior (2006). Absorption spectra were obtained on filtrate (0.2 μm

pore size) for CDOM, and filters for phytoplankton and NAP (before and after bleaching). Exponential decreases with increasing wavelength (400-700 nm range) for a_{CDOM} and a_{NAP} , and bimodal patterns for a_{phyto} , are reported. Dependencies of a_{phyto} and a_{NAP} on the common water quality metrics of chlorophyll *a* and suspended solids are evaluated. Wide spatial differences in the magnitudes of the three components and their relative contributions to overall *a* are documented. Cross-sectional comparisons are made between the five lakes.

Keywords: Dissolved organic matter, Distribution patterns, Remote sensing.

PERNICA, P.¹ and WELLS, M.G.², ¹Department of Physics, University of Toronto, Toronto; ²Department of Physical and Environmental Sciences, University of Toronto, Toronto. **Wind Driven Mixing of the Surface Waters of Lake Opeongo, Ontario.**

Patchiness of phytoplankton in Lake Opeongo has been linked to wind speed, with heterogeneous distributions occurring at wind speeds of 3-7m/s (Richards, 2007). The variations in wind velocity are also thought to directly affect the structure of the mixed layer of the lake. In July 2008, current data in the water column of the mixed layer in Lake Opeongo, Ontario was measured. Sampling was done over thirty-one transects each 2 km in length, where velocity was measured from the surface to a 5m depth in 10 cm bins. Three components of current velocity were measured using an Acoustic Doppler Current Profiler (ADCP) sampling at 0.5 Hz and temperature profiles were collected using a CTD. For wind speeds of 3-7 m/s local Richardson numbers demonstrated a weak temperature stratification and the presence of velocity shear. At wind speeds greater than 7 m/s measurements indicated a well mixed velocity profile. These variations in the structure of the mixed layer will be compared with the spatial patterns of phytoplankton in the lake. *Keywords: Air-water interfaces, Turbulence.*

PERSOON, C.L. and HORNBUCKLE, K.C., 1. Dept. of Civil and Environmental Engineering, IIHR-Hydroscience and Engineering, University of Io, 4105 Seamans Center for Engineering, Iowa City, IA, 52242. **Airborne PCB Congeners in Chicago and Cleveland.**

PCBs originating in urban atmospheres have been shown to contribute to mass loading of PCBs into the Great Lakes. However, the relative concentrations and congener distributions of PCBs between specific urban areas along the Great Lakes have not been extensively compared. This study compares congener distributions and concentrations between two urban areas, Chicago and Cleveland, collected by passive sampling methods (PAS-PUF) simultaneously during the summer of 2008. Results of congener specific analysis show that concentrations of PCBs throughout Cleveland are higher than those in Chicago. Congener distributions between the two urban areas differ as well, with Chicago's distribution being more enriched with lower chlorinated PCBs than Cleveland. Finally, spatial distributions of total PCB concentrations in both urban areas show a higher variability in spatial distribution of concentrations than Chicago. *Keywords: PCBs, Passive Sampling, Urban Areas.*

PERSOON, C.L.¹ and KLECKA, G.M.², ¹Dept. of Civil and Environmental Engineering, IIHR-Hydroscience and Engineering, University of Iowa, Iowa City, IA, 52242; ²2. Environmental

Chemistry Research Laboratory, Toxicology and Environmental Research & Consulting, The Dow Chemical Company, Midland, MI, 48674. **Evaluation of Current Chemicals of Emerging Concern in the Great Lakes.**

Chemicals of Emerging Concern (CECs) in the Great Lakes were researched and published reports were categorized and reviewed. Data from these reports were compiled into a data base by the International Joint Commission, and data was then analyzed for the entire Great Lakes region. In all, compiled data for eight categories of CECs, Alkylphenol Ethoxylates, novel flame retardants (excluding PBDEs), synthetic musks, organic waste compounds –personal care products (OWC-PCP), novel pesticides, pharmaceuticals, and short-chained chlorinated paraffins (SCCP), were statistically analyzed and sample locations mapped for the Great Lakes. Reported are results for each chemical category and individual analyte within that category, for mean concentration, standard deviation, median, 95th and 5th percentiles, and minimum and maximum reported concentrations. *Keywords: Database, Great Lakes, Emerging contaminates.*

PETERSON, B.M.¹, CORY, R.M.¹, MCNALLY, A.M.¹, FUNKE, M.M.², THOEMKE, J.D.³, COTNER, J.B.², and MCNEILL, K.P.³, ¹Department of Chemistry, University of Minnesota, Minneapolis, MN, 55455, United States; ²Department of Ecology, Evolution, and Behavior, University of Minnesota, Minneapolis, MN, 55455, United States; ³Department of Chemistry, Minnesota State University-Mankato, Mankato, MN, 55455, United States. **Optical and Photophysical Parameters of Lake Superior Dissolved Organic Matter.**

Following a survey of Lake Superior, the bays were identified as having unique optical, photophysical, and molecular weight characteristics from the open lake. To further investigate these parameters, a more in-depth study was undertaken during two summers in the Western Arm of Lake Superior where the St. Louis River is located. These parameters, including absorbance coefficients, fluorescence index, spectral slope and size exclusion chromatography, were all studied to determine whether they are possible proxies for terrestrial dissolved organic matter (DOM). Due to our interest in reactive oxygen species, singlet oxygen steady state concentrations and quantum yields were also measured and offer a unique insight into the dissolved organic matter. Both of these measurements are rarely reported in spite of singlet oxygen's role in dissolved organic matter transformations. *Keywords: Photolysis, Lake Superior, Dissolved organic matter.*

PETERSON, H.M.¹, NIEBER, J.L.¹, KANIVETSKY, R.¹, SHMAGIN, B.A.², and WELLS, J.³, ¹University of Minnesota, 1390 Eckles Avenue, St. Paul, MN, 55108-6005; ²Water Resources Institute, Box 2120, 229 Agricultural Engineering, Brookings, SD, 57007; ³Minnesota Environmental Quality Board, 658 Cedar Street, Suite 300, St. Paul, MN, 55155. **Atlases of Water Resources for Minnesota as a Tool for Sustainable Community Planning.**

The long history of cartography and the recent digital revolution have culminated in the Google-map portal with unprecedented daily use. As an example of a map product, water resource sustainability maps may also be useful for planning human development and protecting ecosystems. A large part of the area of the State of MN belongs to the St. Lawrence watershed,

and in a project funded by the LCCMR the University of Minnesota is developing water resource sustainability atlases at a statewide scale, and for three regions and three counties. These atlases are being developed using river flow monitoring data available from USGS for Minnesota and bordering areas of North Dakota, South Dakota, Iowa and Wisconsin. These atlases will provide the quantitative framework regarding water balance components as related to landscape diversity, and the multi-scale maps of water availability for Minnesota. The combination of a cyber model of landscapes, multidimensional methods of data analysis, and GIS cartography used for map creation open ways to examine river flow records in concert with ground water level data and climate data to develop the relationships needed to quantify and map the distribution of ground water recharge and annual/seasonal runoff in times of climate change. *Keywords: Spatial analysis, Planning, Climate change.*

PEYER, S.M., MCCARTHY, A.J., and LEE, C.E., Department of Zoology, University of Wisconsin, Madison, WI, 53706. **Plasticity in Shell Shape and Byssal Thread Synthesis Rate: Do they Contribute to the Displacement of Zebra by Quagga Mussels?**

Throughout the Great Lakes of North America, the invasive zebra mussel (*Dreissena polymorpha*) is being displaced by the invasive quagga mussel (*D. bugensis*) in shallow habitats. Zebra mussels only appear to dominate over quagga mussels in habitats with high water velocity. Environmentally-induced plasticity in shell shape and byssal thread synthesis rate might provide insights into competition and niche partitioning between the two species. We examined shell shape and growth of morphologically distinct shallow and deep quagga mussels exposed to levels of temperature, food quantity, and water motion that are typical in shallow versus deep habitats. We also tested for differences in byssal thread synthesis rate between zebra and quagga mussels in response to water velocity. Quagga mussels showed a high degree of developmental plasticity in shell shape, but zebra mussels had much greater plasticity in byssal thread synthesis rate. Tradeoffs between allocation to byssal threads versus shell growth might contribute to competition and niche partitioning between zebra and quagga mussels. While zebra mussels have higher allocation to byssal threads and dominate in habitats with high water velocity, quagga mussels have higher growth rate and attain larger body size, possibly allowing them to overtake zebra mussels in calmer habitats. *Keywords: Biological invasions, Dreissena, Zebra mussels.*

PIERCE, L.R.¹, WILLEY, J.C.², CRAWFORD, E.L.², and STEPIEN, C.A.¹, ¹Lake Erie Center, 6200 Bayshore Rd., Oregon, OH, 43618; ²George Isaac Cancer Research Center, 3120 Glendale Ave., Toledo, OH, 43614. **A Rapid Molecular Assay with Internal Controls for Detecting the VHS Fish Virus.**

The emerging viral hemorrhagic septicemia (VHS) disease is caused by the new rhabdovirus strain IVb that broke out in the Great Lakes in spring 2006 and 2007, causing massive fish die-offs that threaten fisheries, economic development, tourism, aquaculture, and public health perception. We are developing key molecular genetic tools for a rapid and accurate polymerase chain reaction (PCR)-based kit to detect VHSv and discriminate among its strains in infected fish. The current "gold standard" cell culture laboratory assay takes weeks, and is laborious and expensive. Our test uses standardized reverse transcriptase, StaRT-PCR, with built

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in synthetic internal controls to quantify the virus. Each sample is measured relative to a known number of synthetic internal standard molecules, and has a lower detection threshold enabling detection of a single VHSV molecule in infected samples. We are comparing our results to those from cell culture and alternate RT-PCR methodology that does not incorporate synthetic internal standards. Our test is 1000x more sensitive than cell culture, has intrinsic quality control, a low detection threshold, and is designed to detect all variant strains. This test will enable more rapid, reliable, and accurate verification of VHSV within hours aiding in fisheries management.

Keywords: Fish, Ecosystem health, Genetics.

PIJANOWSKI, B.C.¹, RAY, D.K.¹, KENDALL, A.D.², and HYNDMAN, D.², ¹Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN, 47906; ²Department of Geological Sciences, Michigan State University, East Lansing, IN, 48824. **Land Use Legacy.**

We couple two spatial-temporal models, a backcast land use change model and a groundwater flow model, to develop what we call “land use legacy maps”. We quantify how a land use legacy map, created from maps of past land use and groundwater travel times, differs from a current land use map. We show how these map differences can impact land use planning and watershed management decisions at a variety of spatial and temporal scales. Our approach demonstrates that land use legacy maps provide a better accurate representation of the linkage between land use/cover and current water quality compared to the current land use map. We believe that the historical signatures of land use impacts on current water quality should be considered in land use planning and watershed management. *Keywords: Watersheds, Urbanization, Hydrodynamic model.*

PLAIN, R., 978 Tashmoo Avenue, Aanishnaabek of Aamjiwnaang/Turtle Island Environmental Resources, Sarnia, ON, N7T 7H5, Canada. **A Community Tie – the Connection of the Aanishnaabek of Aamjiwnaang with the St Clair River.**

The river was a member of the community, it fed us, cleansed us, it cooled us on the hot summer days. The St Clair’s fingers reached out through the community like veins. We, the Aanishnaabek of Aamjiwnaang, have lived with the river for as far back as the Elders can remember. This presentation is of the Aanishnaabek of Aamjiwnaang and how our culture, our language, our community was tied to the waters of the St Clair. Today we fight to hold onto those little pieces of our past, our culture, our language and our community tie to the River. The St Clair River is now an Area of Concern because of pollution. The river was made famous when the “BLOB” (a mixture of 18 chemical contaminants found at the bottom of the St. Clair River near Sarnia in 1985) came to life. To us, the St Clair River contains the medicines we need to revive ourselves, to bring the balance back into our community. Through the implementation of the *Great Lakes St. Lawrence River Basin Sustainable Water Resources Agreement*, major water withdrawals and consumptive uses in the Great Lakes Basin will be regulated to ensure no significant individual or cumulative impacts to water quantity and quality (e.g. to ensure the quality of return flow and the hydrologic system’s ability to process contaminants and nutrients). *Keywords: St. Clair River, First Nations, Community.*

PORTA, M.J., EDWARDS, W.H., and BUR, M.T., USGS Great Lakes Science Center, Lake Erie Biological Station, 6100 Columbus Avenue, Sandusky, OH, 44870. **A Comparison of Three Methods for Estimating Ages of Lake Erie White Perch.**

Precisely aging sport and commercially harvested fish is essential for fisheries managers when tracking mortality rates and population age structures over time; therefore, finding an aging structure that gives the most accurate age estimate with great consistency for a particular species is critical. We compared ages estimated from otoliths, scales, and dorsal spine cross sections, for white perch *Morone americana* from western Lake Erie. These structures were collected from 196 commercially harvested white perch during April and May 2008. Seven age classes were present in this study, with ages ranging from age 3 to age 10. Percent reader agreement was greatest for otoliths at 96%. Age estimates from both scales and dorsal spine sections showed greater variability when compared to estimates from otoliths. Scales tended to underestimate the ages of fish when compared to otoliths, especially when fish were greater than age 5. We suggest using otoliths for age estimation in white perch where precise age estimates are needed, because age estimation errors may produce incorrect management decisions. *Keywords: White perch, Fish aging.*

POSTE, A.E.¹, HECKY, R.E.², and GUILDFORD, S.J.², ¹University of Waterloo, 200 University Ave. W., Waterloo, ON, N2L 3G1; ²University of Minnesota-Duluth, 2205 East 5th St., Duluth, MN, 55812. **Seasonal Variability of Microcystin Concentrations in Murchison Bay and Napoleon Gulf (Lake Victoria, East Africa).**

Lake Victoria (East Africa) is a critical source of water for over ten million people as well as for large populations of domestic and wild animals. However, cultural eutrophication has led to an increase in the frequency of toxic cyanobacterial blooms in the lake. In order to gain an understanding of the factors encouraging active production of the cyanotoxin microcystin, samples were collected from two embayments in northern Lake Victoria (Murchison Bay and Napoleon Gulf) on a bi-monthly basis between September 2008 and February 2009. Samples were collected for analysis of chlorophyll and nutrient concentrations, determination of phytoplankton community composition, and detection of microcystin through ELISA. Microcystin concentrations were found to be consistently higher in Murchison Bay (1.00–28.67 µg/L; mean: 7.37 µg/L) than in Napoleon Gulf (0.25–4.01 µg/L; mean: 1.75 µg/L). At both study sites microcystin concentrations regularly exceeded the WHO guideline for drinking water of 1 µg/L, indicating that microcystin concentrations may be detrimental to the health of the people and animals that rely on these embayments for water. We explore the physico-chemical and biological factors that influence microcystin concentrations in these embayments. *Keywords: Africa, Harmful algal blooms, Lake Victoria.*

POTHOVEN, S.A.¹, FAHNENSTIEL, G.L.¹, and VANDERPLOEG, H.A.², ¹N.O.A.A. Great Lakes Environmental Research Lab, 1431 Beach St, Muskegon, MI, 49441; ²N.O.A.A. Great Lakes Environmental Research Lab, 4840 State Rd, Ann Arbor, MI, 48108. **Mysis in Southern Lake Michigan.**

Mysis relicta abundance and life history characteristics have been extensively studied at a site in southeastern Lake Michigan (off Muskegon, Michigan) since 1995. Other lower food web and water quality parameters have been concurrently monitored in the same region since the 1980s. Abundance of *Mysis* on average has declined 85% at a nearshore site (45 m) and 70% at an offshore site (110 m) between 1995-2002 and 2007-2008. We will examine trends in *Mysis* life history characteristics (size, reproductive patterns, distribution) as well as environmental factors such as primary production, phytoplankton composition, zooplankton abundance, transparency and fish predation to elicit possible mechanisms behind the observed decreases in *Mysis* abundance. *Keywords: Lake Michigan, Macroinvertebrates, Zooplankton.*

POULOPOULOS, J. and CAMPBELL, L.M., Department of Biology and School of Environmental Studies, Queen's University, Kingston, ON, K7L 3N6. **Can Archived Museum Ichthyology Collections be used to Determine Shifts in Historical Food Web Structure over Time? Evidence from Lakes Nipigon and Simcoe, Ontario.**

Great Lakes ecosystems have been subjected to many disturbances over the last century, including non-native species, mercury contamination, construction of dams and other infrastructure, and changes in fisheries practices and management. It is known that aquatic food webs have been altered by these disturbances, but historical webs are not well understood, so it is difficult to fully gauge the changes. Many museums house large ichthyology collections that have the potential to fill this knowledge gap. We review the use of stable isotope analysis in the study of archived fish, and discuss the assumptions and limitations of this technique. We also present results from our stable isotope and mercury analyses on archived fish from Lakes Nipigon and Simcoe, large lakes within the upper Great Lakes basin. These results show that food web structures have largely maintained the same “shape”, but this shape has become more compressed, meaning that species’ diets overlap today more than in the past. Also, some species’ diets have noticeably shifted, while others have not, revealing a species-specific effect of the disturbances on the food web components. Museum ichthyology collections have the potential to provide important new insights into food web change, and have broad applications in Great Lakes management. *Keywords: Stable isotope analysis, Mercury, Museum.*

PROCTOR, M.E.¹, SLOSS, B.L.¹, JANSSEN, J.², and RISE, M.³, ¹WI Cooperative Fishery Research Unit, 800 Reserve St, Stevens Point, WI, 54481; ²Great Lakes WATER Institute, 600 E. Greenfield Ave, Milwaukee, WI, 53204; ³Ocean Sciences Centre, Memorial University of Newfoundland, St. John's, NL, A1C 5S7. **Assessing Our Abilities to Distinguish Among Lake Trout Hatchery Strains and Their Potential Hybrid Offspring on Lake Michigan's Mid-Lake Reef Complex.**

Multiple strains of lake trout (*Salvelinus namaycush*) are currently stocked in Lake Michigan as part of efforts to restore lake trout populations. Reproductive behavior and viable eggs/fry have been documented on the mid-lake reef complex (a highly productive historical spawning region). A key facet of restoration efforts is to focus propagation on those strains that survive and successfully reproduce. Our objective was to determine if a contemporary genetic

dataset and any of six statistical algorithms could accurately identify pure strain and interstrain hybrid individuals. Simulated genotypes (seven loci) were constructed based on data from previous lake trout genetic studies. Three Bayesian and three ML assignment methods were used to predict the genetic composition of various simulated admixtures. Genetic diversity levels among the strains allowed moderate confidence in the assignment of progeny to a single strain, but limited accuracy in predicting F_1 or F_x hybrids. NewHybrids showed the most promise for correctly assigning hybrid offspring, but this method is limited by a maximum of two reference populations. Additional lake trout-specific microsatellite markers were developed to aid in distinguishing among Lake Michigan lake trout. *Keywords: Population restoration, Genetics, Lake trout.*

QUINN, F.H., 701 Red Mill Dr, Tecumseh, MI, 49286. Relative Roles of Climate vs Erosion in the Recent Decrease in Fall between Lakes Huron and Erie.

The fall, difference in elevation, between Lakes Huron and Erie is one means of assessing permanent lowering of Lake Huron water levels. It has decreased from 2.8 m in the 1860s to 1.9 m at the present time. Major past changes are due to navigation projects, sand and gravel dredging, isostatic rebound, and diversions. However, the recent episode of major lowering of Lake Huron water levels with respect to Lake Erie has occurred at a time in which no dredging was conducted. Controversy currently exists over whether this lowering of water levels is due to major decreases in water supplies, the erosion of the bed of the St. Clair River following navigation projects or high lake levels, or a combination of both. This study uses a combination of water level gauge relationships, St. Clair and Detroit River fall comparisons, and St. Clair River flows computed from a Lake Erie water balance to assess the erosion contribution. The analysis indicates a drop of Michigan-Huron water level, and a resulting drop in fall, of about 5-8 cm due to channel erosion for the recent episode. The remaining decrease in fall between Lakes Huron and Erie, 43-45 cm between 1985 and 2006, is due to a combination of decreased water supplies on the upper lakes and increased water supplies to Lake Erie. *Keywords: Lake Huron, Hydrologic budget, St. Clair River.*

RAMIN, M., ZHANG, W., GUDIMOV, A., and ARHONDITSIS, G.B., Physical & Environmental Sciences, University of Toronto, Toronto, ON, 1265 Military Trail, Canada. Environmental Risk Assessment and Adaptive Management Implementation in Hamilton Harbour.

In water quality management, mathematical models are used to understand ecological processes, to predict aquatic ecosystem dynamics, to evaluate management alternatives/climatic scenarios, and to support the policy making process. Environmental models involve substantial uncertainty due to the structure of the models and parameters used. Failure to account for model uncertainty could provide flawed results and lead to the misallocation of limited resources during the costly implementation of environmental management schemes. We have developed a Bayesian Network of eutrophication models for the Hamilton Harbour in Western Lake Ontario and make use of Bayesian uncertainty analysis techniques for rigorously assessing the uncertainty in model predictions. Some of the anticipated benefits from this research, such as the

elucidation of the key causal links associated with the formation of toxic cyanobacteria (*Microcystis*) blooms, the estimation of critical loads for pollutants based on acceptable probabilities of compliance with water quality goals, the optimization of the sampling design of future monitoring programs of the system, and the alignment with the policy practice of adaptive management, will aid stakeholders and policy makers when making decisions for sustainable environmental management in the Hamilton Harbour. *Keywords: Lake management, Model testing, Eutrophication.*

RANDALL, R.G.¹, BROUSSEAU, C.M.¹, and HIRIART-BAER, V.², ¹Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6, Canada; ²Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Long-term trends in an Index of Biotic Integrity for Nearshore Fishes in Hamilton Harbour.**

As part of the Great Lakes Action Plan, the coastal fish community in Hamilton Harbour, a designated degraded area (IJC), was monitored by boat electrofishing since 1988. An Index of Biotic Integrity (IBI), which is based on community metrics from the fish catch data, increased between 1988 and 2008. Changes in the IBI were associated with increases in species diversity and turbidity-intolerant species as well as with decreases in non-native species. During this 20-yr period, several ecosystem-level changes have occurred in these areas as a result of management or the introduction of invasive species (e.g. dreissenid mussels and Round Goby). The Great Lakes IBI integrates the effects of four main factors influencing the fish community: non-native fishes, water quality, physical habitat, and piscivore abundance. Understanding the reasons for changes in the IBI is critical for future management, but it is challenging because of the multiple stressors that have impacted the fishes. Despite the increases in the IBI in recent years, average values for Hamilton Harbour continue to be lower than the IBI at other coastal areas of Lake Ontario. *Keywords: Lake Ontario, Ecosystem health, Fish.*

RAY, D.K. and PIJANOWSKI, B.C., Forestry and Natural Resources, Purdue University, West Lafayette, IN, 47907. **Simulating Historical Landcover Maps for the Muskegon River Watershed.**

We simulated the historical land use of the Muskegon River Watershed using a GIS and neural network based model. The simulated land use was from 1978 to 1900 at yearly timesteps. Since the transition pathways of land use change are not clearly known we used a variety of land use transition rules for land transformation between urban, agriculture, forest and shrubs. Combination of these rules resulted in 12 different model variants. We validated our model using aerial photographs from the 1970s, 1960s, 1950s and the 1930s. Different model variants had different levels of simulation accuracy. The model results served as the starting point for conducting subsequent model simulations of water quality and fish abundance. *Keywords: Model studies, Land use change modeling, Historical landcover.*

READ, J.G.¹, CHILD, M.², and MANNY, B.M.³, ¹Michigan Sea Grant, 440 Church Street, Suite 4044, Ann Arbor, MI, 48109; ²Essex Region Conservation Authority, 360 Fairview Avenue

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

West., Suite 311, Essex, ON, N8M 1Y6; ³USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105. **Managing Collaborations for Native Fishery Enhancement: Case Studies in the Binational Detroit River.**

Conceiving, planning, coordinating and funding fishery habitat enhancement projects, in particular spawning sites, in high velocity/volume rivers such as Great Lakes connecting channels is a very challenging process. In the Lake Huron to Lake Erie corridor – St. Clair River, Lake St. Clair and Detroit River connecting channels – a multidisciplinary group of federal, state/ provincial, municipal, university and private agencies and organizations has come together to address the need for enhancing limited fishery habitat. Over the past six years this group has undertaken two such projects and identified additional opportunities in the corridor. This presentation will address funding strategies, “care and feeding of partnerships,” discuss motivations – why individuals/agencies participate, and how these complex projects are managed. We will use the Belle Isle Sturgeon Spawning Habitat Project and the Fighting Island Lake Sturgeon Project as our case studies. *Keywords: Fish, Habitats, Management.*

READ, J.G., Michigan Sea Grant, 440 Church Street, Suite 4044, Ann Arbor, MI, 48105, US. **Spawning Habitat for our Key Native Fish.**

Much of the spawning habitat for our key native fish has either been destroyed or contaminated in the Lake Huron to Lake Erie Corridor – St. Clair River, Lake St. Clair and Detroit River (HEC). In the HEC, a multidisciplinary group of federal, state/ provincial, local, university and private agencies and organizations has come together to address the need for enhancing limited spawning habitat. Over the past six years this group has undertaken two such projects and identified additional opportunities in the corridor. This presentation will discuss restoring fish spawning habitat and the steps that scientists go through to select locations, design a reef/nursery site and construction considerations that are made. Two examples, the Belle Isle Sturgeon Spawning Habitat Project and the Fighting Island Lake Sturgeon Project will be case studies.

REDDER, T.R.¹, DEPINTO, J.V.¹, TAO, H.¹, TURNER, C.L.¹, SWACKHAMER, D.L.², and CARLSON, D.L.², ¹LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108; ²Environmental Health Sciences, 807 Mayo Mail Code, University of Minnesota, Minneapolis, MN, 55455.

Development and Application of a Multi-media Screening Model for Chemicals of Emerging Concern in the Great Lakes Basin (GLMOD).

Physically-based, multi-media models have great potential to support the assessment and management of chemicals of emerging concern, as well as guiding the development of research and monitoring programs for these contaminants. We have developed a screening level, multi-media model (GLMOD) that can be used to establish a quantitative relationship between the sources and the ultimate fate and effects of emerging chemicals. GLMOD has been configured to represent the Great Lakes basin, including the water column and bottom sediments for the lakes, the watersheds, and the atmosphere overlying the basin. The land area within the basin is segmented into 120 major watersheds, and 12 water/sediment segments are used to represent the

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

Great Lakes system. The land and water segments are overlain by a 50-km grid of the troposphere. The model represents all potential exposure pathways for chemical from source (air, land, or water discharge) to top predator fish, and also calculates human and ecological effects. GLMOD has been field-tested for six PCB congeners and six PBDE congeners, spanning a range of partitioning characteristics. A series of diagnostic evaluations has been conducted with the model for both sets of congeners to illustrate the potential impact of localized sources on specific exposure locations throughout the basin. *Keywords: Great Lakes basin, Mathematical models, Organic compounds.*

REDISKE, R.R. and REDISKE, J.D., Annis Water Resources Institute, 740 W. Shoreline Drive, Muskegon, MI, 49441. **The Role of *Cladophora* and *Spirogyra* Mats in the Sequestration of *E. coli* and Microcystin in Saginaw Bay and Grand Traverse Bay.**

Cladophora and *Spirogyra* are filamentous green algae that form thick mats that wash on shore and foul beaches in the Great Lakes. The proliferation of these algae mats along the shores of the Great Lakes is thought to be a result of invasive zebra and quagga mussels altering the nearshore cycling of nutrients. In addition to fouling the beaches with decaying organic matter, *Cladophora* and *Spirogyra* mats are known to concentrate *E. coli* and the cyanobacteria toxin microcystin in the nearshore waters. Eight beaches in Saginaw Bay and six beaches in Grand Traverse Bay were sampled in 2008 at the same locations used for public health monitoring. Samples were collected at three locations at each beach at depths of 0.1-0.3 m within 2 hours of the scheduled collection for public health monitoring (1 m depth). Samples were analyzed for *E. coli* using the Colilert18 method (IDEXX) and microcystin LR and RR by HPLC/MS. High levels of *E. coli* were found in the in the algal mats at both locations (200-10,000 CFU/g DWT). Microcystin was detected at all of the Saginaw Bay sites with a maximum level of 530 ug/kg DWT found at the Bay City Beach. Microcystin was not detected in the Grand Traverse Bay Samples. *Keywords: Cladophora, Harmful algal blooms, E. coli.*

REUTTER, J.M.¹, FORTNER, R.W.², and BILLS, T.³, ¹Ohio Sea Grant and Stone Lab, 100 Research Ctr., 1314 Kinnear Rd, Columbus, OH, 43212; ²COSEE Great Lakes, 113 Paula Circle, Oak Island, NC, 28465; ³Pierce Middle School, 5145 Hatchery Road, Waterford, MI, 48329. **What is Pedagogy and Why Should Scientists Care? (Pedagogy 101).**

Results of COSEE's scientist survey at IAGLR indicated that many scientists were not familiar with the constructivist approach to teaching and learning, and had only basic understanding of how classrooms interpret the terms "hands-on" instruction, "cooperative learning," and "inquiry." This session addresses basic terminology used by science teachers to describe their professional methods, and offers insights into how people learn science. Many scientists believe that teachers will present more science if they are simply provided with science information, but this is not often the case. Knowledge of pedagogy [strategies, techniques, and approaches that teachers can use to facilitate learning; the science and art of teaching] can facilitate scientists' outreach into classrooms and foster collaboration with teachers. The presentation offers a scientist's perspective on the need for guidance on pedagogy, and an

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

educator's direction on how "pedagogical content knowledge" should influence the way scientists relate to K-12 audiences. *Keywords: Education, Scientists, Pedagogy.*

RICKETTS, R.D. and COLMAN, S.M., Large Lakes Observatory, 2205 E. 5th Street, Duluth, MN, 55812. **The Large Lakes Observatory, University of Minnesota Duluth: An Institute Focused on Oceanographic Research on Large Lakes Around the World.**

The Large Lakes Observatory was formed in 1994 on the Duluth campus of the University of Minnesota and is the only institute in the country dedicated to the study of large lakes throughout the world. We take an oceanographic approach to basic research to understand physical, chemical, biological, and geological processes operating in large lakes. Our faculty and researchers work on lakes ranging from the East African rift lakes to lakes in Central Asia and the North American Great Lakes. Our areas of research include aquatic chemistry, circulation dynamics, geochemistry, acoustic remote sensing, plankton dynamics, sedimentology and paleoclimatology. We have an extensive suite of equipment to facilitate this research including mass spectrometers, gas chromatographs, an X-ray fluorescence core scanner, numerous other pieces of analytical equipment for inorganic and organic chemical analyses, as well as an extensive suite of oceanographic equipment. We run the largest University owned research vessel on the Great Lakes, the Blue Heron, which is capable of operating on all of the Great Lakes and open to use by all scientists. Undergraduate and graduate students work with the faculty and on the Blue Heron as they obtain MS and PhD degrees in Biology, Chemistry, Physics, Geology, Environmental Science or Water Resources Science. *Keywords: Institute, Lacustrine research, Environmental education.*

RIDDLE, C.M., One Maritime Plaza, 4th Floor, Toledo, OH, 43604. **The Lake Erie Balanced Growth Program – Overview.**

The Lake Erie Protection & Restoration Plan was adopted by the Ohio Lake Erie Commission in 2000. The Plan, which was prepared with the participation of many Lake Erie stakeholders, experts, and officials concluded that the "quality of Lake Erie is a reflection of the quality of the entire watershed." The Plan established a priority strategic objective to "infuse best available Balanced Growth principles in local land use decision making." A Blue Ribbon Task Force came together to establish two documents, which guide the implementation of the Balanced Growth Program, under the title "Linking Land Use and Lake Erie", published in 2004. Since then, implementation of the program has followed, with four pilot watershed planning projects, and a comprehensive program to promote Best Local Land Use Practices to local governments across the watershed. Key characteristics of the Balanced Growth Program include its voluntary nature, with an emphasis on incentives for local governments and developers, and its implementation without significant additional legislation or regulation. This presentation will act as the introduction to two other presentations focused on specific aspects of the Balanced Growth Program. *Keywords: Watersheds, Planning, Balanced growth.*

RISENG, C.M.¹, WILEY, M.J.¹, STEVENSON, R.J.², PIJANOWSKI, B.C.³, and DAVID, D.W.², ¹School of Natural Resources and Environment, University of Michigan, Ann Arbor, MI, 48109; ²Departments of Zoology and Geology, Michigan State University, Lansing, MI, 48824; ³Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN, 47907.
Muskegon Futures: Riverine Biotic Assessment.

The status of aquatic resources in the Muskegon River watershed (MRW) was assessed in 2001-2002 using multiple physical and biological parameters: water chemistry, sediment transport, algae, invertebrates, mussels, and fish (Stevenson). We constructed models that predicted observed vs. expected condition from landscape and point source variables for riverine systems. Using these models in combination with Classified Regression Tree models, we predicted the expected condition of physical, chemical and biotic integrity under different future land use and climate scenarios (Pijanowski, Hyndman & Wiley). We found that the percent of biotic impairment in rivers increased from 8% in 2002 to 31% in 2070 depending on rates of urban sprawl, agricultural development, and reforestation and that a futures scenario with a combination of decreasing rates of urban sprawl and increasing rates of reforestation would have minimal effects on biotic integrity. We also identified tributaries and sub-basins more sensitive to development and where land use management will have the most positive effect on biological systems. *Keywords: Assessments, Bioindicators, Model studies.*

ROBERTS, J.J.¹, HÖÖK, T.O.², LUDSIN, S.A.³, GRECAY, P.A.⁴, VANDERPLOEG, H.A.⁵, and POTHOVEN, S.A.⁵, ¹University of Michigan, School of Natural Resources and Environment, CILER, 4840 S. State Rd., Ann Arbor, MI, 48108-9719; ²Purdue University Department of Forestry and Natural Resources, 195 Marstellar, West Lafayette, IN, 47907; ³The Ohio State University, Department of Evolution, Ecology and Organismal Biology, AEL, 1314 Kinnear Rd., Columbus, OH, 43212; ⁴Salisbury University, Department of Biological Sciences, Salisbury, MD, 21801; ⁵National Oceanic and Atmospheric Administration, Great Lakes Environmental Research Laboratory, 4840 S. State Rd, Ann Arbor, MI, 48108. **Sub-Daily Behavioral Consequences of Hypoxia for Yellow Perch in Lake Erie's Central Basin.**

Hypolimnetic hypoxic (< 2 mg O₂L⁻¹) conditions develop within Lake Erie's central basin during late summer. Previous results suggest that yellow perch (*Perca flavescens*) mean diet, distribution, and condition are affected by hypoxia within Lake Erie's central basin. To explore the subtle behavioral mechanisms leading to these ecological consequences we integrated field and laboratory methods. Stationary fishery acoustics and trawl sampling were used to assess sub-daily vertical movement of yellow perch within hypoxic and normoxic habitats. In the laboratory, we exposed yellow perch to fluctuating oxygen conditions and examined effects on consumption. Preliminary results suggest that yellow perch will undertake brief foraging forays into hypoxic habitats, but that consumption is not significantly affected by such behavior. However, there may be additional energetic costs of yellow perch undertaking these hypoxic foraging forays. Detailed understanding of such sub-daily behavior may be crucial to determine organismal effects of ecosystem level changes such as hypoxia. *Keywords: Fish behavior, Lake Erie, Yellow perch.*

ROBSON, M.E.¹, GILBERT, B.², HELM, P.A.², MELYMUK, L.E.³, DIAMOND, M.L.¹, BLANCHARD, P.⁴, and BACKUS, S.⁵, ¹Dept. of Geography, University of Toronto, Toronto, ON; ²Environmental Monitoring & Reporting Branch, Ontario Ministry of Environment, Toronto, ON; ³Department of Chemical Engineering & Applied Chemistry, University of Toronto, Toronto, ON; ⁴Air Quality Research, Environment Canada, Toronto, ON; ⁵Ontario Water Quality Monitoring, Environment Canada, Burlington, ON. **Polycyclic Musks in Toronto Rivers: The Effects of Urbanization and High Flow Events.**

Polycyclic musks (PCMs) are a class of persistent organic pollutants that are widely used in a variety of personal care products. Although of limited toxicity, they have recently become of considerable concern due to their ubiquity in the environment, having been found in, river water, sea water, air sediments, and wildlife through out the globe. One of the key pathways through which these chemicals are believed to enter the environment is via waste water discharges to rivers and lakes. To investigate this, we analyzed 5 PCMs (Celestolide (ADBI), Phantolide (AHMI), Traseolide (ATII), Galaxolide (HHCB)) in bulk water samples from 11 sites in rivers in the Greater Toronto Area that drain into Lake Ontario. Measurements were taken under a range of flow regimes. Concentrations of Σ_5 PCMs ranged from 3540 to 19240 ng/L, with a distinct trend of increasing concentrations as a function of urbanization. Low flow regimes also had consistently higher concentrations than high flow regimes, which has important implications for source identification. Galaxolide (HHCB) and Tonalide (AHTN) were consistently most abundant of the 5 compounds, contributing from 79 and 17 %, respectively, of the total mass of PCMs on average. *Keywords: Polycyclic musks, Urbanization, Watersheds.*

ROBSON, M.E.¹, MELYMUK, L.E.¹, GIANG, A.¹, CSISZAR, S.¹, DIAMOND, M.L.¹, HELM, P.A.², BLANCHARD, P.³, and BACKUS, S.⁴, ¹University of Toronto, Toronto, ON; ²Environmental Monitoring & Reporting Branch, Ontario Ministry of Environment, Toronto, ON; ³Air Quality Research, Environment Canada, Toronto, ON; ⁴Ontario Water Quality Monitoring, Environment Canada, Burlington, ON. **Continuing Sources of PCBs: The Significance of Building Sealants.**

Despite the phase out of polychlorinated biphenyl (PCB) production in the 1970s, PCBs remain a ubiquitous environmental contaminant due in part to their presence in materials and equipment still in use. One of these materials is permanently elastic sealants containing PCBs, used in buildings constructed from 1950-70. Building sealants are important as they represent a considerable percentage of the remaining PCB stocks and, by the very nature of this use, they are classically open sources. Their use in building exteriors leaves them permanently exposed to a wide variety of loss processes, such as volatilization, wash off and erosion. Thus they potentially constitute an important ongoing source of PCBs to the wider environment. To investigate the extent of these sealants as a source, a screening campaign and GIS-based stock estimation was undertaken for the city of Toronto, Canada, which experienced a building boom from 1950-70. Of the 95 buildings selected, 13 had detectable concentrations of PCBs in sealants, with concentrations ranging from 0.6 to 82 mg/g, (mean: 4.6 mg/g). Based on these results, 14% of buildings constructed from 1950 to 1980 still have PCB-containing sealants. The estimated total stock of PCBs in building sealants in Toronto is 0.141-231 tonnes, with a best estimate of 13 tonnes. *Keywords: PCBs, Urban areas, GIS.*

RODENBURG, Z.L., ERDMAN, N.R., SMITH, J.L.H., EASTLING, P.M., and HORNBUCKLE, K.C., Dept. Civil & Environmental Engineering, University of Iowa, Iowa City, IA, 52242. **Persistent Organic Pollutants found in the 2008 Flood Residues of Cedar Rapids, Iowa.**

Extreme flooding of rivers may contribute to increased loading of persistent organic pollutants (POPs) to the Great Lakes, the Mississippi river, and other large lakes and surface waters downstream of industrial and urban areas. This study examines the fate of POPs that were mobilized during heavy flooding of the Cedar River and the small urban city of Cedar Rapids, Iowa during the summer of 2008. This study focuses on three representative organic pollutant groups: the pesticide chlordane, polychlorinated biphenyls (PCBs), and synthetic musk fragrances. We hypothesize that these compounds were mobilized by the flood water and that residues of these compounds remained in the soils and sediments of the residential areas of the city. To test our hypothesis, soil samples were collected from ~200 of residential locations in the downtown Cedar Rapids area and analyzed for the three compound groups. Samples were extracted using an accelerated solvent extraction (ASE 300) system, and analyzed using GC/ECD, GC/MSD and GC/MS/MS. This poster compares the results of the study, including a comparison of data collected from both within and outside the flood zone. *Keywords: PCBs, Pesticides, Sediment quality.*

ROERDINK, A. and KRAMER, J.W., National Center for Water Quality Research, Heidelberg College, Tiffin, OH, 44883. **Separation and Analysis of Algal Pigments by High-Performance Liquid Chromatography with Fluorescence Detection.**

The Western Basin of Lake Erie has recently experienced cyanobacterial blooms more severe than those of the 1990s, and comparable to those of the 1970s. In connection with a project to remotely sense developing blooms, we have developed a method to separate algal pigments and analyze them by HPLC. Pigments were collected from aqueous samples by passing them through a glass fiber filter. The filters were frozen at -20°C for a minimum of 48 h, then divided in half and placed into a test tube with 90% acetone (chlorophyll) or phosphate buffer (phycocyanin), and sonicated for 30 min. Chlorophyll pigments were determined by HPLC using a monolithic column. Phycocyanin was determined by filter fluorometry. Use of the monolithic column instead of a conventional particle-packed column decreased analysis time from 35 min to 9 min while maintaining separation efficiency and resolution of pigments. While this method requires analysis in the lab, it has several advantages over in situ fluorometry: pigment concentrations are obtained by direct measurement rather than by estimation from a fluorometric spectrum, clumping and masking effects are eliminated by extracting the pigment from the cell, and matrix effects are eliminated by measuring all pigments in the same matrix. *Keywords: Chemical analysis, Cyanophyta, Harmful algal blooms.*

ROFKAR, J.R., DUNCAN, A.M., BARNSWELL, K.D., ARMENIO, P.M., FRANTZ, J., and HECKATHORN, S.A., Dept. of Environmental Sciences, University of Toledo, Toledo, OH, 43606. **Effects of Nitrogen on Boron Toxicity in *Azolla caroliniana*.**

Boron (B) is an essential plant micronutrient, yet most species tolerate a narrow concentration range of B, so B stress is common. We examined effects of nitrogen (N) on B toxicity in the N-fixing aquatic fern, *Azolla caroliniana*, to determine if B-stress responses are N costly and if *Azolla* can be used in wetland remediation or restoration of B pollution. Plants were grown (14 d) in complete nutrient solutions with 0 or 1mM N and 0.5, 10, or 500 μ M B. The highest B level increased plant B concentration 10-fold relative to the low and medium B treatments (which did not differ). Added N increased total mass, coverage area, and number of plants, and decreased soluble carbohydrate content; however, high B decreased growth (especially roots) only at 0 N. High B had little effect on photosynthesis, and decreased carbohydrates only at high N. Hence, B stress responses were limited primarily by N resources, and perhaps limited by C only at high N. Further, compared to many species, *Azolla* is tolerant of very high B levels when N is non-limiting, indicating that *Azolla* is a candidate for use in restoration and remediation of B-contaminated wetlands. *Keywords: Environmental contaminants, Nutrients, Wetlands.*

ROOK, B.J.¹, HANSEN, M.J.¹, and GORMAN, O.T.², ¹University of Wisconsin - Stevens Point, Stevens Point, WI; ²United States Geological Survey, Lake Superior Biological Station, Ashland, WI. **Cisco Recruitment Dynamics in Lake Superior, 1978-2005.**

Historically, the cisco was the most abundant fish species in each of the Great Lakes, but by the mid-1900s, the species was absent throughout most of the basin. Overfishing, habitat degradation, and exotic species introductions caused cisco yield to decline by 96.3% in Lake Ontario, 99.5% in Lake Erie, 94.9% in Lake Huron, 99.5% in Lake Michigan, and 80.4% in Lake Superior. Cisco recovered in portions of Lake Superior, but abundance is now driven by highly erratic recruitment. Management agencies have begun exploring the feasibility of restoring cisco throughout Lake Superior and the entire Great Lakes basin, but limited understanding of factors that drive recruitment variation, and the spatial scale at which factors operate, remain barriers to restoration. We used a generalized version of the Ricker stock-recruitment model to identify the appropriate spatial scale for modeling and to identify and quantify the effects of biotic and abiotic factors on cisco recruitment in Lake Superior. We found that recruitment should be modeled on a regional scale. Factors correlated to recruitment included wind speed during hatching, rainbow smelt biomass during hatching, density of other cisco age classes during hatching, and temperature at 13-14 months of age. *Keywords: Lake Superior, Recruitment, Fish populations.*

ROSAUER, D.¹, SITAR, S.², JOHNSON, R.³, and GOETZ, F.R.¹, ¹Great Lakes WATER Institute University of Wisconsin-Milwaukee, 600 E. Greenfield Ave., Milwaukee, WI, 53204; ²Marquette Fisheries Research Station, 484 Cherry Creek Rd., Marquette, MI, 49855; ³Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, WA, 98112. **A Phenotypic Comparison of Lake Trout (*Salvelinus namaycush*) Morphotypes.**

In Lake Superior, there are three principal lake trout (*Salvelinus namaycush*) morphotypes: leans, siscowets and humpers. Wild lean and siscowet lake trout differ in lipid content, and in head, eye, and fin morphology. In addition, siscowets are deepwater forms (>80 meters), while leans inhabit shallower (<80 meters) depths. It is unknown whether the differences in morphology and lipid content between these morphotypes are a result of genetic or environmental differences that they experience as a result of the different depths that they inhabit. To address this question, we obtained fertilized wild lean and siscowet eggs and are rearing them to adults under identical environmental conditions (e.g., temperature and feed). Approximately 3 months post swim-up, 500 leans (adipose clipped) and 500 siscowets were mixed and held in flow-through tanks at 9°C. The fish are periodically analyzed for growth, lipid content, and morphometry. Analysis of length and weight indicates that siscowets are growing more quickly than leans and there are significant differences in the condition factor between morphotypes. Truss analysis has revealed multiple truss elements differing significantly between the morphotypes. Lipid analysis has shown significantly higher levels of fat in siscowets compared to leans. *Keywords: Morphotype, Lake Superior, Lake trout.*

ROSEMAN, E.F., O'BRIEN, T.P., and DALEY, B.A., USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105. **Larval Fish Community of the Detroit River.**

The Detroit River is a viable spawning and nursery area for Great Lakes fishes and also serves as a corridor for larval fish 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 larval fish community to document spawning success of river residents as well as movement of fishes from upstream sources. Sampling was conducted from March - June in 2006 and 2007 and March - May in 2008 to assess species composition, timing of occurrence, density, growth, and transport of larvae in the river and into western Lake Erie. Weekly active sampling was conducted using bongo nets in main channel and nearshore areas. Species found during 2006-2008 include burbot, deepwater sculpin, lake whitefish, walleye, yellow perch, rainbow smelt, suckers, muskellunge, smallmouth bass, longnose gar, carp, emerald shiner, gizzard shad, alewife, white bass, white perch, darters, and troutperch. We will present data showing the timing and magnitude of abundance for select species and also compare the 2006-2008 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 river. *Keywords: Detroit River, Fish populations, Plankton.*

ROSSMANN, R., USEPA Large Lakes Research Station, 9311 Groh Road, Grosse Ile, MI, 48138. **Estimation of a Historic Mercury Load Function for Lake Michigan using Dated Sediment Cores.**

Box cores collected between 1994 and 1996 were used to estimate the history mercury loads to Lake Michigan. The Pb-210 dated cores were used to estimate the storage of total mercury in the lake's sediments, excluding Green Bay, to be 228 metric tons. One of the cores

was selected to be representative of the time variation of mercury loads to the lake. Its selection was based on having a minimum mixed layer thickness, a high sedimentation rate yielding a surface interval representing roughly one year, a location responsive to major sources of mercury, and a flux variation representative of that seen in all cores. A plot of mercury flux versus date was normalized to the calculated mercury storage in the lake by setting the area under the curve equal to the storage. This was then back calculated for each dated interval of the core. Missing years were obtained by linear extrapolation between the core intervals. The load calculated for 1994 was 1157 kg/y. This is significantly higher than the observed load of 768 kg/y. The source of the difference is believed to be missed loads due to sparse atmospheric deposition stations, shoreline erosion loads, and timing of tributary sampling. The flux of 1157 kg/y in 1994 was the lowest it has been since 1892. This abstract does not necessarily reflect EPA policy. *Keywords: Pollution load, Lake Michigan, Mercury.*

ROWE, M.D.¹, PERLINGER, J.A.¹, and FAIRALL, C.W.², ¹Michigan Technological University, 1400 Townsend Dr., Houghton, MI, 49931; ²NOAA Earth System Research Lab, 325 Broadway, Boulder, CO, 80305. **Application of an Internal Boundary Layer Transport Exchange Model to Micrometeorological Measurements of Hexachlorobenzene Gas Transfer in Lake Superior.**

A two-dimensional Lagrangian internal boundary layer transport exchange (IBLTE) model was developed to predict the modification of temperature, humidity, and trace gas concentration and flux as a function of fetch in offshore flow. The model was designed to complement over-water flux measurements. The model incorporates the NOAA COARE gas transfer model to calculate turbulence scaling parameters and gas transfer velocity. The model was applied to HCB flux measurements performed along a transect in Lake Superior in July, 2006. Measurements were taken at 16, 28, and 59 km fetch under off-shore flow conditions. Modification of concentration, air temperature, and flux with fetch resulted from fetch-dependent equilibration, growth of the IBL, and variation of lake surface temperature during the transect experiment. Good agreement was obtained between modeled and measured fetch-dependent concentration modification. Modeled HCB fluxes were greater than measured fluxes at the 16- and 28-km stations but nearly equal at the 59-km station. Error analysis indicated that the measured flux at the 59-km station was significantly different from zero and had a smaller uncertainty than flux calculated by the two-film model. *Keywords: Air-water interfaces, Atmosphere-lake interaction, Toxic substances.*

RUCINSKI, D.K.¹, BELETSKY, D.², DEPINTO, J.V.¹, SCAVIA, D.³, and SCHWAB, D.J.⁴, ¹501 Avis Dr., Ann Arbor, MI, 48108; ²G110 Dana, 440 Church St, Ann Arbor, MI, 48109; ³440 Church St, Ann Arbor, MI, 48109; ⁴4840 S. State Rd, Ann Arbor, MI, 48108. **Application and Comparison of 1D and 3D Lower Food Web Models 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. To investigate how nutrient loading may still be contributing to hypoxia in the lake, two lower food

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

web models were developed and applied in tandem. The first model employs a one-dimensional domain for the Central Basin of Lake Erie, while the second model expands the grid to three-dimensions and covers the entire lake. Both models share the same lower food web kinetics, including available and unavailable nutrients, detritus, phytoplankton, and zooplankton dynamics. Model results are compared to dissolved oxygen, chlorophyll, nutrient and carbon observations; and a comparison of the computed duration and extent of hypoxia is presented. The importance of applying a three-dimensional model to this system is highlighted, such as the need to capture complex hydrodynamic transport and the implications of nutrient cycling in near shore areas. *Keywords: Hypoxia, Eutrophication, Lake Erie.*

RUDSTAM, L.G., JACKSON, J.R., and HOLECK, K.T., Department of Natural Resources, Cornell University Biological Field Station, Bridgeport, NY, 13030, US. **Cornell Biological Field Station.**

Cornell Biological Field Station was established in 1956, over 50 years ago. Early research involved walleye and yellow perch in Oneida Lake; however the Field Station has maintained an active program in the Great Lakes since the 1970s, particularly in Lake Ontario but also in Lakes Erie and Champlain. Current activities include biomonitoring of lower trophic levels in Lake Ontario together with New York DEC, Ontario MNR, and USGS, the 2008 Lake Ontario Lower trophic levels Assessment with EPA, acoustic surveys of fish and mysids with NYSDEC and OMNR, and studies of invasive species like *Hemimysis anomala* (in Lake Ontario with USGS, OMNR, NYDEC, and DFO), alewife (in Lake Champlain, with Univ Vermont and Vermont Fish and Game) and cormorants (with APHIS). This active program builds on a long list of earlier studies on Lakes Ontario and Erie by Dr Ed Mills. As Dr Mills is retiring in 2009, we show a few background slides on his work on the Great Lakes as well as take a look at the future of Great Lakes research at the Cornell Biological Field Station at Shackelton Point in the post-Mills era. *Keywords: Lake Ontario, Lake Erie.*

RUPPRECHT, S.M. and PENNUTO, C.M., 1300 Elmwood Ave., Buffalo, Ny, 14222.

Assessing the Swimming Performance of the Round Goby (*Neogobius melanostomus* Pallas 1814) and its Implications for Upstream Migration in Tributary Streams and Rivers.

Round gobies have had negative effects on benthic macroinvertebrate and fish communities in the Great Lakes. Recently, gobies have migrated into tributary streams, but little is known about the physical characteristics of streams or the swimming performance of gobies which might determine invasion success. Several species of Gobiidae scale waterfalls using various combinations of swimming and use of fused pelvic fins. Since round gobies also have fused pelvic fins, we examined the effect of water velocity, substrate, and body size on swimming performance to estimate which conditions might limit upstream migration. We determined whether fin morphometrics scaled allometrically or isometrically with body weight. Preliminary results showed that adult gobies spent equal amounts of time swimming when tested over smooth or pebble substrates, but time spent swimming decreased at higher velocities. Pectorals were used in lower velocities; whereas caudal fins were used in higher velocities for pebble substrate. There was an isometric relationship between the fused pelvic fin area and body

weight for adults, indicating waterfall scaling would not be possible. Combined, these data suggest that streams with water velocities as high as 85 cm/s would be susceptible to goby invasion, but that dams or waterfalls should be effective barriers *Keywords: Swimming performance, Exotic species, Spatial distribution.*

RUTHERFORD, E.S., NOAA - Great Lakes Environmental Laboratory, Ann Arbor. **Effects of Urban Development and Climate Change on Fisheries Habitat Suitability in the Muskegon River Watershed: Results of a Multi-Modeling Approach.**

We examine how rates of climate change and urban development and reforestation in the Muskegon River watershed affect habitat suitability for key gamefish species (walleye, steelhead, Chinook salmon, smallmouth bass) with a multi-modeling system. Basin-wide land use change and hydrologic models forecast alterations in the ecosystem's water budget. Local-reach hydraulic models and temperature models provide a high-resolution, spatially-explicit depiction of the physical environment. We linked spatially-explicit weighted usable area models for key life stages (eggs, juveniles, adult) to output from the physical models, and ran land use scenarios and climate change scenarios representing landscapes in years 1998, 2010, 2020, 2040, 2070 and 2100. The land use scenarios reflected: 1) expected urban development (baseline), 2) urban development under a 'slow growth' regime, and 3) baseline with reforestation. WUA model results indicate climate change has a greater effect than land use change on habitat for the fish life stages and species considered.

SALAMOVA, A. and HITES, R.A., School of Public and Environmental Affairs, Indiana University, Bloomington, IN, 47405. **Persistent Organic Pollutants in Tree Bark.**

The goal of this study was to demonstrate that tree bark is an easy and inexpensive way to monitor persistent organic pollutants in air. For these purposes, 20 tree bark samples were collected at five Integrated Atmospheric Deposition Network (IADN) sites (Eagle Harbor, MI; Chicago, IL; Sleeping Bear Dunes, MI; Cleveland, OH; and Sturgeon Point, NY). These tree bark samples were analyzed for polybrominated diphenyl ethers (PBDEs) and non-PBDE brominated flame retardants (BFRs), polychlorinated biphenyls, and selected chlorinated pesticides. Tree bark concentrations of these compounds were compared to IADN 2007 atmospheric data for PBDEs, PCBs, and pesticides. BDE-47, BDE-99, and BDE-209 were the most abundant congeners at almost all sites, suggesting that the penta-BDE and deca-BDE products are the main sources of PBDEs to these trees. Also, PBDE concentrations were higher at highly populated sites, such as Chicago and Cleveland, as compared to less populated sites, such as Eagle Harbor and Sleeping Bear Dunes. Other brominated flame retardants, such as decabromodiphenyl ethane and 1,2-bis(2,4,6-tribromophenoxy)ethane were detected in some samples. *Keywords: Atmospheric circulation, IADN, PBDEs.*

SANDERSON, L.M. and VINCENT, R.K., 190 Overman Hall, Bowling Green, OH, 43403. **Mapping the Phycocyanin Concentrations of the Great Lakes Using LANDSAT ETM+ Data.**

Microcystis algal blooms, which contain a pigment known as phycocyanin, are extremely toxic algae which can harm fish and mammals. The objective of this study was to develop a multiple regression model to map the phycocyanin concentrations in the Great Lakes. A total of over 350 LANDSAT 7 images which were cloud free and obtained during the period of October, 2007 to September, 2008 were downloaded from the USGS EROS center web site. Water samples from 30 sampling locations were collected during the LANDSAT overpass, with a GPS point taken at each collection point. The water samples were then analyzed for phycocyanin content in the laboratory. Regression equations were established to search for algorithms that could map the phycocyanin concentrations in the water using six, dark-object-subtracted (DOS) LANDSAT bands. The algorithm model that was developed was then successfully tested for robustness by applying it to other LANDSAT images. Also field samples were taken periodically over the course of time to ensure the accuracy of the model. Our results enabled us to conclude that it is indeed possible to map and estimate the toxic phycocyanin concentrations of the *Microcystis* algal blooms. The ability to predict these *Microcystis* blooms could help lead to the prevention of these blooms and save fish, livestock, and people. *Keywords: Remote sensing, Algae.*

SASS, D.J.¹, BERTRAM, P.², and STADLER-SALT, N.³, ¹Oak Ridge Institute for Science and Education, 77 West Jackson Boulevard (G-17 J), Chicago, IL, 60604, US; ²U.S. Environmental Protection Agency, 77 West Jackson Boulevard (G-17 J), Chicago, IL, 60604, US; ³Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R4A6, Canada. **Changes in the Great Lakes Nearshore 1996-2008.**

In 1996, a paper on nearshore waters, was prepared for the State of the Lakes Ecosystem Conference (SOLEC), this paper was updated for SOLEC 2008. We present highlights for these nearshore papers and include a discussion of the emerging issues of botulism, harmful algae blooms, viral hemorrhagic septicemia (VHS), and shoreline development, among other stressors. For example, in 1996, the most destructive human activity for the nearshore waters was identified as the introduction of exotic species. At this time there were 166 documented invasions of non-indigenous aquatic species in the Great Lakes since the early 1800s. In 2008, at least 184 invasions have now been reported. Although nutrient loadings to the Great Lakes have been reduced in the past 30 years, many physical, chemical and biological changes to the nearshore environment remain. *Keywords: Emerging Issues, Changes 1996-2008, Nearshore Waters.*

SCHANTZ, S.L., University of Illinois, 2001 S. Lincoln Ave., Urbana, IL, 61802, USA.
Human Health Impact of Contaminants in Great Lakes Fish.

Polychlorinated biphenyls (PCBs) are no longer used commercially, but remain prevalent in Great Lakes fish. Animals or humans exposed to PCBs during early development show deficits on learning tasks that require inhibitory control. PCB-exposed animals and humans also do poorly on behavioral tasks where low rates of responding are optimal, including differential reinforcement of low rate (DRL) operant schedules. We have reported learning deficits on tests

of cognitive flexibility and working memory in PCB-exposed rats. More recently we have observed that PCB-exposed rats earned fewer reinforcers than controls on a DRL task. Drug challenges with amphetamine disrupted performance of PCB-exposed rats to a lesser extent than controls, suggesting reduced brain dopamine function. Both the deficits in response inhibition and the altered response to amphetamine are similar to patterns observed in children with attention deficit hyperactivity disorder (ADHD). We are also evaluating the effects of polybrominated diphenyl ethers (PBDEs), which are also prevalent in Great Lakes fish, on behavior and brain dopamine function—both alone and in combination with PCBs. Because of their structural similarity, the potential for additive effects of PCBs and PBDEs is a concern. Supported by ES11263 and ES015687 from NIEHS and R82939001 from USEPA.

Keywords: PCBs, Human health, Methylmercury.

SCHLOESSER, D.W.¹, SOSTER, F.², EDWARDS, W.J.³, MATISOFF, G.⁴, and KRIEGER, K.A.⁵, ¹USGS, Great Lakes Science Center, Ann Arbor, MI, 48105; ²DePauw University, Greencastle, IN, 46135; ³Niagara University, Lewiston, NY, 14109; ⁴Case Western University, Cleveland, OH, 44106-7216; ⁵Heidelberg College, Tiffin, OH, 44883. *Hexagenia* spp. in Western Lake Erie-- an Update of Abundance of this Sentinel Taxon.****

In the mid 1950s, mayfly nymphs (*Hexagenia* spp.) disappeared from many nearshore waters of the Great Lakes. Then in the mid 1990s, mayflies recolonized western Lake Erie. In 1995-1996, nymphs were present at low densities (ca. 50 130/m²) but adults were so abundant they disrupted electrical power generation and created automobile hazards near shore. Between 1997 and 2005, densities fluctuated between 204 and 539 nymphs/m² but impacts of annual emergences declined as institutions mediated impacts of emergences through maintenance activities. Recent data has reinforced a hypothesis of a density-dependent relationship with a 'boom-and-bust' cycle that now regulates abundance of mayfly nymphs in western Lake Erie. Such a density-dependent regulation is contradictory to the historical-eutrophication, all-or-nothing hypothesis that explained the absence of mayflies between the mid1950s and the early-1990s. If a density-dependent hypothesis of mayfly regulation is proven to be correct, meaningful endpoints for this taxon used in management-restoration plans may need to be reevaluated for western Lake Erie and, possibly, elsewhere in the Great Lakes. *Keywords: Lake Erie, Macroinvertebrates, Environmental health.*

SCHLOESSER, D.W.¹, ROBBINS, J.², NALEPA, T.F.², and MOOREHEAD, N.², ¹USGS, Great Lakes Science Center, Ann Arbor, MI, 48105; ²NOAA, Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 48105. *Burrowing Mayflies (Hexagenia* spp.) in Saginaw Bay, Lake Huron: Paleoecologic and Historic Records.****

As a key indicator taxon, burrowing mayflies (*Hexagenia* spp.) have been used in setting lake-wide management goals for restoration. However, many areas of the Great Lakes lack records to determine if mayflies are endemic and therefore, a logical restoration goal. In the present study, we construct a chronologic record of the relative abundance of mayflies in Saginaw Bay, Lake Huron through the use of mayfly tusks and ¹³⁷Cs dating of sediment and historic records. Abundance of tusks in sediments; (1.) was relatively low between 1770 and

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

1800, indicating nymphs were endemic in the bay, (2.) increased and remained abundant between 1815 and 1959, in response to increased nutrients from European-watershed development, and (3.) declined dramatically after 1959, as a result of nymph extirpation caused by excessive nutrients and anoxia. Historic records verify nymphs were absent in the bay since the mid-1950s. In the early-1990s and 2000s, observations of nymph and adult mayflies indicate that mayflies may be beginning to re-colonize Saginaw Bay after an absence of half-a-century. Undoubtedly, watershed conservation, three decades of pollution abatement programs, and possible impacts of zebra mussels have set the stage for a possible recovery of burrowing mayfly nymphs in Saginaw Bay. *Keywords: Benthos, Environmental health, Green Bay.*

SCHNARS, J.L., TREC, Suite 9, 301 Peninsula Drive, Erie, PA, 16505. **The Regional Science Consortium: Environmental Research and Education.**

The Regional Science Consortium (RSC) at the Tom Ridge Environmental Center at Presque Isle in Erie Pennsylvania is a collaborative, non-profit organization that facilitates education and research for the Lake Erie and Upper Ohio River basin. Institutions enroll at a full, associate, or affiliate membership level and are represented on the Board of Directors. Presently, the RSC is comprised of over forty members, including colleges, universities, state and government agencies, and various environmental conservation groups. The RSC occupies a 6,000 square foot laboratory wing and an off-site field lab on Presque Isle State Park. The RSC sponsors an annual research symposium the first week of November allowing researchers and students to present results from previous field seasons. The symposium offers a great venue for the communication and collaboration of research. The RSC continues to offer undergraduate and graduate courses, and workshops (certificate). Courses are evaluated and approved by a curriculum subcommittee comprised of individuals from our Board of Directors. Courses are instructed by scientists and professors from member universities. The RSC also sponsors a monthly Visiting Scientist Speaker Series, featuring local and nationally recognized researchers. This series is free and open to the public. *Keywords: Research, Public education, Education.*

SCHULZ, K.L.¹ and MAYER, C.M.², ¹Department of Environmental and Forest Biology, State University of New York College of Environmental Science and Forestry, Syracuse, NY, 13210; ²Department of Environmental Science and Lake Erie Center, University of Toledo, Toledo, OH, 43618. **Mussel Power and Oligotrophication: Integrating Experiments and Field Observations to Isolate Mechanisms Changing Lake Ecosystem Properties.**

The invasion of *Dreissena* and phosphorus (P) loading abatement are examples of concurrent system alterations; both have been associated with increased water clarity, lower phytoplankton biomass, and increased benthic production. We performed mesocosm experiments in which the density of *Dreissena*, light, and P were manipulated independently to separate their direct and indirect effects. Here we report on effects on pelagic and benthic algal and invertebrate biomass, primary productivity, stoichiometry, and nutrient pools; the direction and magnitude of the separate and interactive effects from our experiments are compared with historical field observations. Results implicate direct grazing and P excretion by *Dreissena* as dominant drivers of change in biomass, production and nutrient cycling in the pelagic, with light

and *Dreissena* presence important mechanisms altering benthos. Experimental quantification of *Dreissena*'s key role in biogeochemical cycling provides an alternative explanation to nutrient loading for recent near shore eutrophication. Although mesocosm experiments are seldom applied to large lake ecology, we argue combining mechanistic experimental results with field observations and modeling provides a powerful means of separating concurrent stressors in the Laurentian Great Lakes. *Keywords: Dreissena, Phosphorus, Ecosystems.*

SCHWAB, D.J.¹ and BUAN, S.D.², ¹NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Road, Ann Arbor, MI, 48108; ²NOAA NWS River Forecast Center, 1733 Lake Drive West, Chanhassen, MN, 55317. **Measured and Modeled Flows in the Grand River, Michigan.**

A horizontal-looking acoustic Doppler current profiler was deployed near the mouth of the Grand River in Grand Haven, Michigan in the fall of 2007. The instrument measured current velocity in the river on a horizontal transect approximately 2 meters below the surface. These measurements were used to estimate total river discharge on an hourly basis. FLDWAV, a one-dimensional unsteady flow model, was used to simulate river discharge for a modeled reach from Grand Rapids to Lake Michigan at Grand Haven. The upstream boundary condition is observed discharge from the U.S. Geological Survey gaging station at Grand Rapids. The downstream boundary condition is Lake Michigan elevation. Lateral inflows to the model are nine creek watersheds totaling 665 square miles between Grand Rapids and Lake Michigan. These creek discharges were simulated using the Sacramento Soil Moisture Accounting Model to simulate runoff and unitgraphs, derived using the Distributed Time Area method, to simulate creek discharges at their confluences with the Grand River. Grand River discharge was simulated on a six-hour time step at the current profiler location and compared to the six-hour average of discharge estimated from the current profiler measurements. *Keywords: Tributaries, Lake Michigan.*

SEEGERS, B.N.¹ and STERNER, R.W.², ¹100 Ecology Building, 1987 Upper Buford Circle, St. Paul, MN, 55108; ²100 Ecology Building, 1987 Upper Buford Circle, St. Paul, MN, 55108. **Lake Superior Deep Chlorophyll Maximum Related to Zooplankton Grazing.**

Lake Superior's Deep Chlorophyll Maximum, located typically at 25-35m, is a persistent lake feature throughout the summer stratified period. The factors causing this DCM are not well understood. Often, in oligotrophic systems a DCM is associated with a nutrient or density gradient. However, previous studies from Lake Superior have not seen measurable nutrient gradients and Lake Superior's DCM is normally located below the density gradient. Another possible contributor is grazing pressure. Intense grazing pressure by the zooplankton community could keep phytoplankton populations low in the relatively warm surface layer. There is an increased abundance of zooplankton above the DCM. In this study, a series of dilution grazing experiments were conducted during six cruises over two years to determine grazing rates above, within and below the DCM. Grazing rates were often highest in the surface layer above the DCM, lowest near the DCM depth and sometimes high again well below the DCM depth. These results are consistent with the hypothesis that this major feature of Lake Superior's ecosystem is

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

caused in part by top-down grazing pressure as a function of depth. *Keywords: Lake Superior, Food chains, Plankton.*

SEELBACH, P.W.¹, NICHOLAS, J.R.², and REEVES, H.W.², ¹Institute for Fisheries Research, 212 Museums Annex, Ann Arbor, MI, 48109; ²Michigan Water Science Center, 6520 Mercantile Way, Lansing, MI, 48911. **A Map to Change the World: Enabling Environmentally Based Water Management across the Great Lakes Region.**

Several groups have been working to develop state and province-scale mapping frameworks for Great Lakes rivers. Each of these sought to provide conceptual, spatial data, and analytical frameworks useful for a variety of management applications. Although not formally coordinated, these efforts have been similar in: identifying riverine spatial units as a data structure; providing complete geographic coverage; inclusion of physical and biological attribute data; and employing landscape-based models to estimate reference benchmarks. In 2008 Michigan established pioneering water law underlain by a powerful rivers mapping framework. This framework provided policy makers with an understandable image of the aquatic resource landscape, and with an ability to view the ecological ramifications of alternative water management standards. It provides the implementing state agency with an efficient tool for data analysis and public education. We encourage the collaborative development of a common rivers mapping framework for the entire Great Lakes region. Although specific applications will differ by jurisdiction and discipline, one base geographic and ecological frame would support development of shared concepts and language, pooling of data and analyses, and development of cohesive and complimentary policies. *Keywords: Environmental policy, Watersheds, Spatial analysis.*

SELDEN, J.D., GOTTGENS, J.F., CRAIL, T.D., MATHIAS, P.T., and HEPPNER, E.A., Department of Environmental Sciences, The University of Toledo, Toledo, OH, 43606, USA. **The Effect of Channel Heterogeneity on Fish Communities in Agricultural Streams in Sandusky and Seneca Counties of Ohio.**

Agricultural streams may provide important headwater habitat for fish but are rarely managed as such. Routine dredging for drainage maintains homogeneous channels. The success of upstream erosion control practices in Ohio since the late 1980s may have reduced the frequency of dredging, thereby promoting the development of heterogeneous channel features (e.g., meanders, vegetated benches). As part of a 4-year project, we sampled 15 streams in the Sandusky River/central Lake Erie drainage. Streams varied in the time since last dredging and, consequently, in their level of channel heterogeneity. In June and September of 2008, almost 8,700 fish (40 % juveniles) belonging to 23 species were identified, assessed for condition, aged and released. Other than a single individual goldfish, non-native fish were absent. Concurrently, we measured water quality, discharge, sediment depth and aspects of channel morphology. Fish abundance, richness and diversity in a single 50m segment were as high as 1,343, 15, and 1.86, respectively. Shannon diversity and species richness increased and Simpson's dominance decreased with greater channel heterogeneity. Sampling will continue in 2009-11. Reduced

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

maintenance dredging, linked with erosion control, may contribute to surprisingly robust and rich fish communities in agricultural streams. *Keywords: Fish, Habitats, Species composition.*

SEPULVEDA VILLET, O.J. and STEPIEN, C.A., Lake Erie Center, University of Toledo, 6200 Bayshore Rd, Toledo, OH, 43618. **Genetic Structure of Great Lakes Yellow Perch: A Landscape Genetic Approach.**

The Yellow Perch is a key sport and commercial fish whose abundances and distribution center in the lower Great Lakes, and particularly Lake Erie. Lake Erie populations have fluctuated historically due to unstable recruitment patterns and exploitation. Fourteen loci are analyzed for 887 spawning samples from Lakes Superior, Michigan, Huron, Erie, and Ontario, including 594 spawning individuals from 13 Lake Erie sites, representing all its current management units and physiographic basins. Analyses include pairwise divergence comparisons, AMOVA partitioning, Mantel regression, genetic distance trees, Bayesian assignment, 3-dimensional factorial correspondence, and Monmonier geographic networks. Results show fine-scale genetic structure distinguishing some spawning groups in Lake Erie. Yellow perch spawning in eastern Lake Erie appear more closely allied to groups in Lake Ontario than to those in western Lake Erie. Patterns in the Great Lakes suggest contributions from at least two primary glacial refugium groups. Lakes house genetically separable population groups, with further population division in most. Primary genetic barriers separate the Upper from the Lower Lakes below Lake St. Clair, with divisions distinguishing Lake Superior and Lake Ontario populations. *Keywords: Great Lakes basin, Genetics, Yellow perch.*

SHACKELFORD, M.T.¹, LONGTON, G.D.¹, BATEMAN, J.D.¹, RACHWAL, J.C.¹, NERUDA, J.A.¹, KOVALAK, W.P.¹, and SCHLOESSER, D.W.², ¹DTE Energy Corporate Service LLC, Land and Water Management, 7940 Livernois H-136, Detroit, MI, 48210; ²USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105. **Distribution and Abundance of Native Mussels (Bivalvia: Unionidae) in a Thermal Discharge in Western Lake Erie.**

Because dreissenid mussels have extirpated native freshwater mussels (Bivalvia: Unionidae) from most of Lake Erie, the present status of unionids inhabiting the thermal discharge at DTE Energy's Monroe Power Plant in western Lake Erie was assessed. Scuba divers collected mussels by handpicking at 38 sites during August-October of 2007 and 2008. Nine species (491 individuals) were collected alive. For all species combined, mean catch/diver-hour was 32 (range 1-122). Estimated mean density was 11/m² (range 0.3-42/m²). For all species, abundance was highest near the mouth of the discharge canal, decreased rapidly to the north and east but diminished more slowly toward the south and west. The overall distributional boundary coincided with the 3 ft contour interval (lwd); an area of ≈1,100 acres that supports an estimated 2-4 million unionids. Greater abundance of unionids near the discharge canal suggests survival in this habitat is directly related to elevated temperature that dreissenids cannot tolerate. Protection from dreissenids decreases with distance from the canal and disappears at depths > 3 ft (lwd) because discharge water no longer contacts the bottom but is suspended over cooler lake water. *Keywords: Western Lake Erie, Unionids, Thermal plume, Benthos, Dreissena.*

SHEAR, H.¹, TOTH, C.², and DA SILVA, S.¹, ¹Geography Dept. UTM, 3359 Mississauga Road North, Mississauga, Ontario, L5L1C6, Canada; ²Town of Oakville, 1225 Trafalgar Road, Oakville, Ontario, L6J 5A6, Canada. **Development of a Set of Environmental Health Indicators for the Town of Oakville, ON.**

In 2003, the Town of Oakville began a process to develop an Environmental Strategic Plan (ESP) to help guide the development of the Town. The Plan was part of "Blueprint Oakville", a long term process that includes plans for transportation, arts and culture, subwatersheds studies, and development charges. The ESP was adopted by Town Council in late 2005. One of the priority actions in the ESP was the development of a set of environmental health indicators as part of an ongoing commitment to report to the public on implementation of the Plan. This presentation will outline the process under which the initial set of indicators was developed, and will provide samples of the 17 indicators adopted by the Town.

Keywords: Indicators, Ecosystem health, Lake Ontario.

SHERRY, J.P., MCMASTER, M.E., DUSSAULT, E.B., PARROTT, J.L., HEWITT, M.L., and BROWN, S.B., Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6, Canada. **An Evaluation of the Health Status of Wild Fish from Wheatley Area of Concern - 1. Biological Effects.**

Environment Canada has initiated studies readdressing fish health issues in the Canadian Areas of Concern, using various measures of endocrine function and overall fish health. The health status of brown bullhead (*Ictalurus nebulosus*) and goldfish (*Carassius auratus*) from the Wheatley Harbour Area of Concern was evaluated during the fall of 2002 and the spring of 2006. Fish health assessments were conducted following the National Environmental Effects Monitoring Programs (EEM) protocol using estimates of age structure, energy storage and energy utilization. Endocrine assessments included plasma steroid concentrations, in vitro steroid synthesis in female fish, plasma concentrations of vitellogenin, and thyroid status. Liver EROD activity was also measured. The gonads were collected and inspected for presence of deformities; liver samples were collected and analyzed for the presence of tumors. Exposure to endocrine disruptors was also investigated by deployment of semi-permeable membrane devices (SPMDs), which were extracted and analyzed using sex steroid binding protein and androgen receptor assays, also used to test pooled liver extracts for the presence of endocrine disrupting chemicals.

Keywords: Fish, Lake Erie, Environmental contaminants.

SHMAGIN, B.A.¹, JOHNSTON, C.A.¹, and KRAKAUER, N.Y.², ¹South Dakota State University, Brookings, SD; ²City College of New York, New York, NY. **Spatiotemporal Regime of Climate and Streamflow in the U.S. Great Lakes Basin.**

We analyzed interannual and seasonal regimes of river runoff, precipitation, and air temperature for three nested regions: (1) the Ontonagon River basin in northern Michigan, (2) the U.S. portion of the Great Lakes Basin, and (3) glaciated portions of the northeastern U.S. spanning from the Dakotas to New England. Data sources included historical records of 50 to

105 yr duration from 45 USGS gauging stations and 198 U.S. National Climate Network stations, and satellite-derived estimates of global monthly precipitation gridded at 2.5 resolution for 1979-2008 (partly data about precipitations were collected and passed for analysis by Glenn Hodgkins from USGS). We examined the spatiotemporal variability of climate characteristics for these regions as a multidimensional structure obtained using factor analysis. The structure consisted of a few (3 to 7) centers of variability for each characteristic, and reflected the diversity of landscapes within the regions examined. Trends and regime shifts for mutual time intervals of river runoff, precipitation and temperature showed different direction of changes. The results obtained at the three scales were generally in agreement. *Keywords: Hydrologic cycle, Regional analysis, Climate change.*

SHUCHMAN, R.A.¹, MEADOWS, G.A.², JENKINS, L.K.¹, HATT, C.R.¹, and PAYNE, J.F.³,
¹Michigan Tech Research Institute, 3600 Green Court, Suite 100, Ann Arbor, MI, 48105;
²University of Michigan, Marine Hydrodynamics Laboratory, 126 West Hall, 1085 S. University Ave, Ann Arbor, MI, 48109-1107; ³North Slope Science Initiative, 222 West 7th Avenue, #13, Anchorage, AK, 99513. **Synergistic Approach to Measuring Lake Properties using Satellite and In-Situ Remote Sensing.**

Radar and electro-optical remote sensing data have been combined with in situ measurements of lakes on the North Slope of Alaska to obtain a baseline characterization of these lakes, determine change detection, document salt water intrusion, and investigate yellow billed loon habitat preference. This multi-faceted program, which also has applicability to the Great Lakes basin, has been aimed at using cost-effect technologies to investigate the remote lakes. In-situ data collected includes measurements using our autonomous water quality and bathymetry mapping robot instruments. ALWAS and BathyBoat robotic data have been used to provide baseline data as well as control and algorithm validation points for satellite remote sensing applications. Specifically, water depths from ALWAS and BathyBoat have been used in electro-optical and radar based water depth algorithms to produce bathymetry and volume of lakes on the North Slope. Additionally, in-situ data from the ALWAS buoys have been used to tune and validate satellite methods to then extend estimates of turbidity, chlorophyll, and salinity (expressed in alterations of aquatic vegetation and shoreline communities) to lakes that have not been directly sampled. These observations can then be linked to trophic index, saltwater intrusion, vegetation, and habitat. *Keywords: Remote sensing, GIS, Water quality.*

SHUCHMAN, R.A.¹, LESHKEVICH, G.A.², HATT, C.R.¹, POZDNYAKOV, D.V.³,
KOROSOV, A.D.³, and JOSBERGER, E.¹, ¹Michigan Tech Research Institute, 3600 Green Court, Suite 100, Ann Arbor, MI, 48105; ²Great Lakes Environmental Research Laboratory, 4840 S.State Road, Ann Arbor, MI, 48108; ³Nansen International Environmental and Remote Sensing Center, Vasilievsky Island 14th Line, 7A, St. Petersburg, 199034, Russia. **Further Steps Towards a Chlorophyll, Dissolved Organic Carbon, and Suspended Mineral Remote Sensing Algorithm for All Laurentian Great Lakes.**

The MTRI/NIERSC algorithm retrieves concentrations of chlorophyll (CHL), dissolved organic carbon (DOC), and suspended minerals (SM). The algorithm was validated (Pozdnyakov

2005), applied in a seven-year inter-annual analysis of SeaWiFS data in Lake Michigan (Shuchman 2006), and recently also applied to all available SeaWiFS/MODIS Lake Michigan data. The algorithm uses a hydro-optical (HO) model that consists of the absorption and backscattering coefficients for CHL, DOC, and SM at each satellite band. During the initial validation of the algorithm, a proxy HO-model from Lake Ontario was used due to a lack of in-situ data in the other Great Lakes needed to create an HO-model for those lakes. Since 2004, GLERL and MTRI have been collecting optical data using a Satlantic multi-spectral profiler, with coincident laboratory measured CHL, DOC, and SM data. Using this data, new HO-models will be created for each Laurentian Great Lake. The new results will be compared with historical in-situ and seasonal phenomena for validation. Also, the differences between the old and new Ontario HO-models will be compared and analyzed. Inter-annual analyses will be performed for each lake after validation. *Keywords: Biogeochemistry, Sediment resuspension, Carbon cycle.*

SIMONIN, P.W.¹, PARRISH, D.L.², RUDSTAM, L.G.³, PIENTKA, B.⁴, and SULLIVAN, P.J.⁵,
¹Vermont Cooperative Fish and Wildlife Research Unit, Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington, VT, 5405; ²U. S. Geological Survey, Vermont Cooperative Fish and Wildlife Research Unit, Rubenstein School, Univ. of VT, Burlington, VT, 5405; ³Cornell University Biological Field Station, Department of Natural Resources, Cornell University, Bridgeport, NY, 13030; ⁴Vermont Department of Fish and Wildlife, 111 West Street, Essex Junction, VT, 5452; ⁵Department of Natural Resources, Cornell University, Ithaca, NY, 14850. **Rainbow Smelt and Alewife Distribution Dynamics in Relation to Temperature and Light in Lake Champlain.**

Rainbow smelt (*Osmerus mordax*) and alewife (*Alosa pseudoharengus*) are anadromous, pelagic fish species native to coastal regions of northeastern North America. Rainbow smelt are native to Lake Champlain, and have occupied a central trophic level supporting higher organisms, including sport fisheries in the lake. However, alewife have recently become established and have the potential to dramatically alter the Lake Champlain ecosystem. The goal of our study was to better understand habitat use dynamics of rainbow smelt and alewife in relation to temperature and light in Lake Champlain. We found alewife young-of-year (YOY) and adults closer to shore and in shallower water than their rainbow smelt counterparts, and YOY rainbow smelt distribution overlapping with adult and YOY alewife. Each trip we collected temperature, dissolved oxygen (DO), pH, conductivity, and light data throughout the water column, and recorded continuous surface light levels. Using these data, we found YOY rainbow smelt, YOY alewife, adult rainbow smelt, and adult alewife distributions best explained by combinations of several variables. This provides a uniquely comprehensive description of factors correlated with rainbow smelt and alewife distribution and feeds into larger analyses and descriptions of the roles of these species in freshwater ecosystems. *Keywords: Alewife, Temperature, Smelt, Light, Distribution patterns, Invasive species.*

SIMPSON, K.E. and BARTON, C.C., Wright State University, 3640 Colonel Glenn Highway, Dayton, OH, 45435. **Temporal Scaling of Dissolved Oxygen Concentration in Fresh Water Environments.**

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

Dissolved oxygen (DO) concentrations from four different aquatic environments within the Great Lakes basin were analyzed along with several other locations in the United States. These different environments include lakes, rivers, lacustaries and streams in order to compare temporal patterns in DO fluctuations. The data were obtained from either the United States Geological Survey or the Office of Ocean and Coastal Resource Management of the National Oceanic and Atmospheric Administration. The power-spectral-density (PSD) was calculated using a Lomb periodogram (for unevenly sampled data) and was plotted versus period to establish functional form of any temporal scaling and also to quantify internal correlation for each time series. The analysis shows that the scaling in each of the environments is a power function with the scaling exponent (β) ranging between 1.2 and 1.6. This range of β indicates that all the time series are self-affine with a moderate level of internal correlation (i.e. are moderately persistent and non-stationary). Those sites with higher flow and turbulence, such as streams and rivers, had higher values of β than those sites with little or no flow and turbulence, such as lakes, reservoirs and lacustaries. *Keywords: Time Series, Complexity, Water quality.*

SINGLER, K.¹ and DEVANNA, K.M.², ¹Ottawa Hills High School, Toledo, OH, 43606; ²Department of Environmental Sciences and the Lake Erie Center, The University of Toledo, Toledo, OH, 43606. **Engaging High School Students in Field Research: Comparing Two Years of Water Quality Data for the Ottawa River.**

As a part of the NSF GK-12 and Student Watershed Watch programs, honors biology students at Ottawa Hills High School measured several water quality parameters on the Ottawa River. Our site was located north of Bancroft Road in the Village of Ottawa Hills near the University of Toledo main campus. We measured dissolved oxygen, nitrate, phosphate, pH, temperature, 5-day biological oxygen demand, turbidity, total solids, and fecal coliforms. The data were collected in October 2008 and compared to data using similar methods collected in October 1994. Dissolved oxygen concentration increased from 4.5mg/L in 1994 to 8.0mg/L in 2008, while the biological oxygen demand over 5 days decreased from 4mg/L in 1994 to 2.5mg/L in 2008. Fecal coliforms increased considerably from 220cfu/100mL in 1994 to 13600cfu/100mL in 2008; however this may have been due to a storm event prior to the 2008 sampling date. Nitrate and phosphate measurements did not change and stayed very close to 0mg/L in both sampling years. Secchi depth did not change and was approximately 1.1m, total solids stayed about 40mg/L, and pH increased slightly from 7.5 in 1994 to 8.0 in 2008. Overall, the total water quality index increased from “medium” in 1994 to “good” in 2008 suggesting improved water quality in the Ottawa Hills region of the Ottawa River. *Keywords: Monitoring, Water quality, Education.*

SMIGELSKI, J.R.¹, TEBBENS, S.F.², and BARTON, C.C.³, ¹Environmental Science PhD Program, Wright State University, Dayton, OH, 45435; ²Department of Physics, Wright State University, Dayton, OH, 45435; ³Department of Earth and Environmental Sciences, Wright State University, Dayton, OH, 45435. **Analysis of Water Level Dynamics in the Great Lakes of North America.**

Anthropogenic as well as natural fluctuations such as precipitation, runoff, snowmelt, retention time, evaporation, and outflow all contribute to water levels observed in the Great Lakes. Verified hourly water level data ranging from 20 to 30 years in duration for five stations in Lake Michigan and four stations in Lake Superior were obtained from NOAA and examined. Analysis of physical processes using nonlinear methods such as the Fourier transform allows one to determine the natural state of the environment and if the natural state fluctuates randomly (white noise) or has some underlying order (persistence). Water level records in the Great Lakes are found to exhibit power law scaling and are thus self-affine over four distinct period ranges. Changes in scaling behavior are observed with inflection points at approximately 1 day, 5 days, and 30 - 60 days. A linear differential equation Frequency Response model of the Great Lakes system as two spring inertial systems coupled together is obtained using Bode analysis and can be applied to explain variations in the Power Spectral Density plots of water levels. Bode plots draw a window into the underlying internal dynamics of the system by analyzing the pattern of change in amplitude across frequencies and are useful in determining how a system will respond to any given input. *Keywords: Water level fluctuations, Signal processing, Model studies.*

SMITH, P.G.R.¹, BRADLEY-MACMILLAN, C.¹, KINGSTON, M.², GRAHAM, A.³, and ARMITAGE, D.⁴, ¹Ontario Ministry of Agriculture, Food and Rural Affairs, 1 Stone Road West, Guelph, ON, N1G 4Y2; ²Agriculture and Agri-Food Canada, 175 Stone Rd. W., Guelph, ON, N1G 4S9; ³Ontario Soil and Crop Improvement Association, 1 Stone Road West, Guelph, ON, N1G 4Y2; ⁴Ontario Farm Environmental Coalition, 100 Stone Rd. W., Guelph, ON, N1G 5L3.

Progress in Adoption of Beneficial Management Practices and Environmental Farm Plans in the Great Lakes Basin 2005-2008.

The Agricultural Policy Framework 2005-2008 provided an historic boost to adoption of Environmental Farm Plans (EFP) and environmental Beneficial Management Practices (BMP) by Ontario farmers in the Great Lakes Basin. 11,778 farm businesses or 23.8% of Ontario farms completed EFPs. 5,683 farms went on to implement 13,726 BMPs under associated cost sharing programs to implement environmental BMP projects. Only BMPs identified through EFP priority setting for each farm are eligible for funding. The 13,726 BMPs resulted in an investment of >\$200 million including over \$100 million from farmers. Exploratory data analysis examined the BMPs adopted by farms of different commodities and geographic distribution. Cross-tabulation of BMPs adopted by farms of different commodity types, show the BMPs adopted address key environmental issues for each commodity. County-level data examined spatial correlations between adoption rates of different BMPs and variables in the 2006 agricultural census. Nutrient management BMP adoption correlated with livestock farms. Soil management BMP adoption correlated with field crop farms. Product, waste, and irrigation BMP adoption correlated with horticultural operations. Results illustrate how the EFP effectively guides each farmer's decision to adopt appropriate BMPs based on local conditions.

Keywords: Environmental policy, Beneficial management practices, Agriculture.

SMITH, R.A. and KRISTOVICH, D., Illinois State Water Survey, 2204 Griffith Drive, Champaign, IL, 61820. **The Influence of the Great Lakes on Passing Cyclones During the Stable Season.**

Previous studies have shown that the Great Lakes have a notable influence on passing extratropical cyclones. A recent climatological analysis found that during the unstable season (September – November), cyclones tended to accelerate as they entered the Great Lakes region, and their rate of intensification would increase while in the region. Despite the change in direction of heat exchanges with the lakes, cyclones tended to behave similarly during the stable season (May – July). We seek to better understand the relationship between the lakes and passing cyclones through examination of 27 stable season cyclones that moved through the region from 2004 – 06, chosen because of a change in the direction of surface heat fluxes during their life cycles. In several cases studies, the passage of one cyclone was followed by decreasing air temperatures, thus creating an unstable environment prior to the passage of a second cyclone. Comparisons showed that the second cyclone lingered in the Great Lakes region longer, and its rate of intensification was greater, than the first cyclone. Results of these case studies will be compared to the wide range of cyclones moving through the Great Lakes region over the three-season time period. *Keywords: Atmosphere-lake interaction, Atmospheric circulation, Climatology.*

SMITHERS-PEART, T.A.¹, SMITH, T.¹, WATSON, S.B.², YERUBANDI, R.¹, EDGE, T.¹, KHAN, I.¹, and BOOTY, B.¹, ¹1220 Fourth Line, Caledonia, ON, N3W 2G1; ²One Young Street, Toronto, ON, L7R 4A6. **Lake Ontario Science Research.**

In response to rising concerns with shoreline and watershed inputs to Lake Ontario, a Collaborative Study was initiated among federal and provincial governments, municipalities and conservation agencies. This partnership has worked together since 2007 to assess the threats and management options to drinking source water in the watershed and along the Canadian shoreline between Niagara and Prince Edward County. As part of this study, focal areas near several major drinking water intakes were monitored on a weekly or biweekly basis at inshore and offshore sites, 2007-2008. This included open water and winter samples in major rivers, drinking water and wastewater treatment plants (WTPs; WWTPs), and inshore and offshore waters. Samples were collected for a range of physicochemical and biological parameters, and linked with moored instrumentation data to evaluate contaminant transport and fate and their threats to WTPs. Here, we focus on phosphorus as a major nutrient regulating biomass and taxonomic composition of the algal assemblages - which in turn directly and indirectly affect water quality and integrity. We present preliminary data showing significant loading from Humber and Credit Rivers and WWTPs, particularly following storm events, and their associated distribution in surface and deep waters in the Lake.

SNYDER, F.L.¹, GOETZ, F.R.², and STEPIEN, C.A.³, ¹Ohio State University Extension, Camp Perry, Bldg. 3, Rm. 12, Pt. Clinton, OH, 43452, USA; ²University of Wisconsin, Great Lakes WATER Institute, Milwaukee, WI, 53201, USA; ³University of Toledo, Lake Erie Center, Toledo, OH, 43618, USA. **VHS Discussion.**

The implications of VHS outbreaks on Great Lakes Ecosystem Health will be discussed. *Keywords: Ballast, Environmental health, Invasive species.*

SNYDER, F.L., Sea Grant Extension, Camp Perry, Bldg. 1, Port Clinton, OH, 43452. **Potential Impacts of VHS Regulations on Great Lakes Fisheries.**

Viral Hemorrhagic Septicemia (VHS) entered North America from Europe years ago as a systemic infection of salmon and trout. A strain of this rhabdovirus is believed to have mutated into a form infecting warm water fishes and now has been found in many Great Lakes fish species. VHS has been linked to die offs of freshwater drum, yellow perch, muskellunge round gobies and other species. The U.S. Dept. of Agriculture's Animal and Plant Health Inspection Service (APHIS) issued a draft order restricting the transportation of live fish on a list of 28 infected species among Great Lakes states and provinces, and has since made minor amendments to this order. Impacts of this order on Great Lakes fisheries have ranged from minor to severe. Aquaculture and commercial fish hauling interests in some instances were unable to market their products, and others faced time consuming and expensive testing protocols. Live bait markets lost several lucrative supply sources and were forced to seek alternate bait species not affected by the federal order. Sport anglers were restricted from transporting live fish, including certain bait species when crossing state or provincial boundaries. In-state boundaries have been established in some states to further restrict the transportation of affected species within those states. *Keywords: Impacts, VHS, Fisheries.*

SNYDER, R.J.¹, DEMARCHE, C.J.¹, and HONEYFIELD, D.C.², ¹Department of Biology, SUNY College at Buffalo, Buffalo, NY, 14222; ²U.S. Geological Survey Northern Appalachian Research Lab, 176 Straight Run Road, Wellsboro, PA, 16901. **Forecasting Impacts of Changing Food Webs in Lake Ontario: Effects of Dietary Fatty Acids on Growth of Alewives.**

A decline in Lake Ontario alewife length and weight has been reported. Concomitant with the changes observed in alewife has been declines of the amphipod *Diporeia* and the opossum shrimp *Mysis*, both of which represent rich dietary sources of lipids and omega-3 fatty acids. To better understand how these food web changes may influence alewife health and growth, we fed alewives isocaloric diets with either corn oil (high in omega-6 fatty acids) or fish oil (high in omega-3 fatty acids) as the main source of dietary lipid. Alewives were fed the experimental diets at either 1% ("low ration") or 3% ("high ration") of their wet body weight per day. After six weeks, alewives maintained on the high ration diets were significantly larger than those fed the low ration diets. Moreover, alewives given the high ration fish oil diet were significantly larger than those maintained on the high ration corn oil diet after six weeks of growth. These results suggest that ongoing food web changes in Lake Ontario may reduce alewife growth rates due to reductions in the availability of dietary omega-3 fatty acids.

Keywords: Alewife, Lake Ontario, Fatty acids.

SPILLMAN, C.M.¹, HIPSEY, M.R.², LEON, L.F.³, BOCANIOV, S.A.³, and SMITH, R.E.H.³, ¹CAWR, Bureau of Meteorology, GPO Box 1289, Melbourne, VIC, 3001, Australia; ²School of Earth and Environment, U. Western Australia, Crawley, WA, 6009, Australia; ³Department of

Biology, University of Waterloo, 200 University Ave. W., Waterloo, ON, N2L 3G1. **A Three Dimensional Model for Dreissenid Mussel Effects on Ecosystem Properties in Lake Erie.**

The colonization of the Great Lakes by dreissenid mussels has been an important ecological event, yet it has been difficult to translate knowledge of mussel distributions and energetics into quantitative estimates of their impacts on ecological processes. An important complication in such estimates is that the access of the bottom-dwelling mussels to the water column is under strong hydrodynamic control while their spatial distributions are often complicated or poorly defined. Here we describe a three dimensional model for Lake Erie (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. The model was initialized with the best available estimates for lake-wide mussel distribution in 2002 and output was compared to in-lake observations and to results of simulations with mussel biomass artificially set to zero. With zero mussel biomass, the model gave reasonable predictions of nutrient and chlorophyll concentrations and simulations with mussel biomass set to realistic values produced very similar results over most of the lake. The implications of this observation and the scope for larger impacts on localized scales will be discussed. *Keywords: Benthos, Hydrodynamic model, Ecosystem modeling.*

STAINBROOK, K.M.¹, CREQUE, S.M.¹, GLOVER, D.C.², and CZESNY, S.J.¹, ¹Lake Michigan Biological Station, 400 17th St., Zion, IL, 60099; ²Auburn University, 203 Swingle Hall, Auburn, AL, 36849. **Delineation of Sediment Type and Composition in Southwestern Lake Michigan and its Relationship to Spawning-Site Preference of Yellow Perch.**

Current maps of Lake Michigan substrate are very general and lack suitable detail of substrate composition and geographic extent of rocky areas. This limits our ability to link biological processes, such as fish spawning and growth, to nearshore habitat and makes it difficult to target structurally-complex habitats for sampling. We compiled substrate information over 72 years for Illinois waters and incorporated it into a GIS framework to generate a more complete picture of sediment type and particle size distribution in southwestern Lake Michigan. Sediment data for 1682 sites was standardized to phi units; natural neighbor interpolation was used in GIS analysis to predict sediment type in areas without data. Predicted sediment values based on this interpolation had a significant positive relationship with observed sediment values ($R^2=0.92$). Historical CPE for yellow perch was significantly higher at sites composed mostly of hard substrate compared to sites with primarily soft substrate. Tagging data indicated that substrate quality affected whether yellow perch returned to their release site in subsequent spawning seasons; higher fidelity was associated with larger, coarser substrate. The generated map, when linked with fisheries data, is a useful tool to further our understanding of habitat's importance in the Great Lakes. *Keywords: GIS, Sediment quality, Yellow perch.*

STAMATI, F.¹, NIKOLAIDIS, N.², and SCHNOOR, J.S.¹, ¹Department of Civil and Environmental Engineering, 4111 Seamans Center, The University of Iowa, Iowa City, IA, 52242; ²Department of Environmental Engineering, Technical University of Crete, University Campus, Chania, 73100, Greece. **Soil Organic Matter Loss Pathways in Agricultural Lands.**

Loss of soil organic matter (SOM) and degrading of its quality makes soils susceptible to erosion with global consequences for food security, climate change, water quality, and economy. Conversion of native lands to agricultural lands results to a loss of SOM. The relative loss of soil OC and ON is a function of climate, soil type-stabilization mechanisms, and agricultural managements. A compilation of literature data presented in this work suggested that the average composite relative slope loss, after the conversion of native grassland to arable tilled land is reducing in time following a logarithmic pattern. The first year loss (10 cm soil depth) is one order of magnitude (i.e. -3.50 tC/ha and -0.54 tN/ha) greater than composite average slope (-0.229 to -0.583 tC/ha y and -0.017 to -0.227 tN/ha y), observed after many years. In this work we aimed at making a gross estimation of the short and long term slope loss of OC and ON in arable tilled lands near floodplain, in two climate extremes environments: Midwest USA (IA) and Mediterranean (Greece). Quantitatively and qualitatively changes, brought about by tillage in five soil aggregate fractions, as well as particle (intra and inter POM) and density fractions (free, occluded, and strongly associated with minerals) within them, were studied (OC, TN, polysaccharides, ¹³C NMR). *Keywords: Dissolved organic matter, Soil organic matter matter loss, Nutrients.*

STAPANIAN, M.A.¹, MICACCHION, M.², and ADAMS, J.V.³, ¹U.S. Geological Survey, 6100 Columbus Ave., Sandusky, OH, 44839; ²Ohio Environmental Protection Agency, 4675 Homer Ohio Lane, Groveport, OH, 43125; ³U.S. Geological Survey, 1451 Green Rd., Ann Arbor, MI, 48105. **Soil Chemistry of Natural and Constructed Wetlands: A Multivariate Approach for Determining Biotic Integrity.**

We examined soil chemistry data for nine natural wetlands and ten constructed wetlands in Ohio. There was no overlap in values of percent total organic carbon (%TOC) between natural and constructed wetlands. Natural wetlands had significantly higher concentrations of %TOC and indices of vegetation integrity (VIBI). We performed an analysis in which concentrations of seven additional analytes (Al, Ba, Cu, Fe, Zn, ammonia, and total phosphorus) were used as predictors of VIBI and type of wetland. None of the seven analytes performed better at screening natural from constructed wetlands than %TOC. We suggest that %TOC can be used as a screening tool and indicator of quality of wetlands soil chemistry. *Keywords: Wetlands, Chemical analysis, Vegetation.*

STEEN, P.J.¹, WILEY, M.J.², and SCHAEFFER, J.S.³, ¹Huron River Watershed Council, 1100 N Main St, Ann Arbor, MI, 48104; ²University of Michigan, School of Natural Resources, 170 Dana Building, Ann Arbor, MI, 48109; ³USGS, Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105. **Predicting Future Changes in Muskegon River Watershed Game Fish Distributions Under Future Land Cover Alteration and Climate Change Scenarios.**

Future alterations in land cover and climate are likely to cause substantial changes in the composition of stream fish communities. Predictive distribution models are an important tool to assess the probability of changes causing species increase, reduction, or extirpation. Classification tree models predicting the probability of game fish presence were applied to the

streams of the Muskegon watershed. Models were applied to three potential future scenarios: 1) land cover change projected through 2100, 2) land cover change and a 3 C increase in air temperature through 2100, and 3) land cover change and a 5 C increase in air temperature through 2100. Analysis indicated the expected change in air temperature and subsequent change in water temperatures resulted in the decline of cold-water fish in the Muskegon watershed by the end of the 21st century while warm-water species increased in range. Changes in land cover were expected to cause large range decreases in a few particular fish species such as walleye and Chinook salmon, but are not predicted to drive major changes in species composition. The combination of land cover change with temperature change indicated that while temperature change has the dominant controlling effect on fish ranges, proper land use management could potentially offset some of these harmful impacts. *Keywords: Climate change, Fish populations, Model studies.*

STEINHART, G.B., MOERKE, A.H., and GREIL, R., Lake Superior State University, 650 W. Easterday Avenue, Sault Ste. Marie, MI, 49783. **Lake Superior State University's Aquatic Research Laboratory: A Small-School Perspective on the Role of Hands-on Experience for Undergraduates.**

In 1977, Lake Superior State University (LSSU) established the Aquatic Research Laboratory (ARL) as part of its Fisheries and Wildlife program. Since that time, the ARL has grown to support training and educating undergraduate students from many departments, conducting ecological research, and providing tours and educational programs. In fact, education, research, and outreach are the basis of the ARL's mission. Although LSSU operates the ARL, it is a joint venture between Edison Sault Electric (ESE) and the Michigan Department of Natural Resources. The ARL includes a fish hatchery, operated by LSSU students, that raises approximately 25,000 Atlantic salmon annually. In addition, the ARL contains office, lab, and meeting spaces supporting a vibrant research program including collaborations with many state, federal, and international agencies, along with other academic institutions. The ARL's location, historical building, and active fish culture and research programs attract over 1,000 visitors per year. A recent gift from ESE of a three-story historical building will allow for a renovated and nearly five-times larger Aquatic Research Laboratory. The renovation will allow for increased fish production and biosecurity, a new fish disease testing laboratory, and expanded teaching, research and outreach facilities. *Keywords: Education, Public education, Great Lakes basin.*

STEPIEN, C.A., Lake Erie Center, University of Toledo, Toledo, OH, 43618. **Research and Education Programs at the University of Toledo's Lake Erie Center.**

The Lake Erie Center (LEC) is dedicated to solving environmental problems at the land-water interface and bay-lake exchanges at the gateway to the upper and lower Great Lakes. Our location on the shores of western Lake Erie next to Maumee Bay State Park provides direct access to lake, agricultural and wetland habitats. Research focuses on linkages among land use, aquatic resources, ecosystem services, and public health. The LEC has beautiful classrooms, laboratories, library, and conference rooms; along with research vessels, wet lab with running lake water, molecular genetics lab, water quality monitoring equipment, and GIS satellite

imagery. Our superb growing graduate and undergraduate programs feature a new \$2.4 million NSF GK-12 program “Graduate Fellows in High School STEM Education: An Environmental Science Learning Community at the Land-Lake Ecosystem Interface” where Ph.D. students mentor high school watershed projects (poster session #35), a new NSF URM program “Undergraduate research and mentoring in land-lake ecosystems”, and our long-running summer NSF REU “Research Experiences for Undergraduates” program. The Lake Erie Center welcomes visiting researchers and students, and use of labs, boats, and meeting rooms. Tour the LEC this Friday afternoon during IAGLR09, <http://www.lakeerie.utoledo.edu>. *Keywords: Lake Erie, Watersheds, Environmental education.*

STEPIEN, C.A. and BROWN, J.E., Lake Erie Center, University of Toledo, Toledo, OH, 43618. **Invasion Genetics of the Round Goby: Founding Sources, Spatial Patterns, and Temporal Changes.**

The genetic composition of an exotic species is regarded as fundamentally important to its ecological success. We test whether the genetic composition of the round goby *Neogobius melanostomus* invasion has changed over its time course, analyze patterns across its range, and identify likely Eurasian founding sources; using mtDNA cytochrome b sequences and 8 nuclear microsatellite loci for 1300+ fish from 22 Eurasian and 25 North American locations, including 2-3 time periods (1993-2007) in Lakes St. Clair (including the original invasion site), Erie, and Michigan (subsequent areas of spread). Invasion genetic findings show: (1) the Black Sea port of Kherson, Ukraine at the Dnieper River was the primary donor population, (2) the invasion has high genetic diversity and no founder effect, (3) high spatial genetic structuring across the exotic and native ranges, (4) some fringe areas fit a “leading edge” model with less genetic variability, whereas others have high diversity with unique alleles from other donor sources, and (5) peripheral sites changed significantly over the invasion’s time course, towards a net gain of alleles, whereas the original sites remained stable. High genetic diversity and divergence across its invasive range likely enhanced the round goby’s ecological success in the Great Lakes. *Keywords: Invasive species, Round goby, Genetics.*

STERNER, R.W., Department of Ecology, Evolution and Behavior, University of Minnesota, St. Paul, MN, 55108, USA. **In situ Measured Primary Production in Lake Superior.**

The presently understood organic carbon budget for Lake Superior is greatly out of balance, with much higher organic carbon losses than identified sources. The primary source for organic carbon is water column production. I used the JGOFS standard protocol to perform seven *in situ* measurements throughout the water column during winter and summer conditions. Basing production on tracer-laden particles harvested on GF/F filters at the end of a 1-d incubation, summer production was approximately $350 \text{ mg C m}^{-2} \text{ d}^{-1}$, not greatly different from early measurements. Winter production using the same method was as low as $90 \text{ mg C m}^{-2} \text{ d}^{-1}$. However, accounting for the total organic carbon production, including radio-label in the dissolved phase at the end of the incubation can approximately double the integral rates. The results suggest that DOC is being produced at high rates and this helps close the Lake Superior carbon balance. *Keywords: Carbon cycle, Productivity, Lake Superior.*

STEVENSON, R.J.¹, WILEY, M.J.², RISENG, C.M.², LOUGHEED, V.L.³, and PIJANOWSKI, B.C.⁴, ¹Center for Water Sciences, Michigan State University, East Lansing, MI, 48824; ²School of Natural Resources and the Environment, The University of Michigan, Ann Arbor, MI, 48109; ³Department of Biological Sciences, University of Texas at El Paso, El Paso, TX, 79968; ⁴Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN, 47906.
Evaluating Thresholds in Ecological Responses to Support Policy and Management Actions.

The Muskegon Watershed Research Initiative is a watershed-scale research program designed to provide the scientific underpinnings to guide management of an ecologically complex Great Lakes Watershed. Land use, hydrology, water chemistry, and biological condition of streams, lakes, and wetlands were determined in a survey of approximately 250 habitats in the MRW. These data, as well as regional data, were used to develop quantitative relationships linking valued ecological attributes, contaminants and habitat alterations, and the human activities in watersheds that were causing ecological alterations. A multi-scaled analysis was used to support plausibility of causal relationships among ecological attributes using regression, structured equation modeling, and an integrated multi-model system simulating watershed behavior. Thresholds in fish, invertebrate, and algal responses along a biological condition gradient were used to set biological condition benchmarks. Thresholds in biological responses along phosphorus and fine sediment gradients were used to set targets for these contaminants. These management benchmarks, delineating state changes, were used to scientifically justify both protection and restoration targets in the watershed. *Keywords: Bioindicators, Watersheds, Management.*

STEWART, K.M., Dept. Biological Sci., Buffalo, NY, 14260, USA. **And a Canal Runs Through It.**

The scenic Hudson River drains an easterly portion of NY State and the big Niagara River drains part of the westerly region of NY State plus four of the five Great Lakes. Additionally, the historic Erie Canal (EC) runs through the state from Buffalo (in the west) to Albany (in the east), but the EC serves more as a conduit than a drain. My 15-year study looked at multiple physical and chemical variables at up to 22 sites (during August) across the half portion of the EC from Buffalo to Syracuse, NY. There tends to be a general west-to-east increase in ionic content in that portion. There are some relatively minor additions and subtractions along this "leaky canal" but, after the initial inflow to the western end of the EC from Lake Erie, the three major influences to the Canal water chemistry seem to be: (1) the Genesee River at Rochester, (2) the Seneca River near Montezuma, and (3) the outflow of Onondaga Lake at Syracuse. Although there are zebra mussels in Lake Erie, and all along the EC, the mean water clarity is highest in the western end of the EC and at two unanticipated sites (Newark and Syracuse) further east. Interestingly, the measured statistical STDev of most variables in the western part of the EC is lower than that further east. One explanation is that this reflects a conservative influence of Lake Erie. *Keywords: Monitoring, Chemical analysis, Turbidity.*

STEWART, S.¹, KOEHLER, N.¹, and TEISAN, J.², ¹21885 Dunham Road, Suite 12, Clinton Township, MI, 48036; ²Harper Woods Secondary School, 20225 Beaconsfield Street, Harper Woods, MI, 48225. **No Scientist Left Behind: Standards 101 (What Every Scientist Needs to Know About Education Standards).**

The US has established a goal that all students achieve scientific literacy. Teachers and researchers share in the responsibility of achieving this goal. Many funding sources require that education and outreach components be included in research proposals. Teachers are given science content standards which outline what K-12 students should know and be able to do in the sciences. Science content knowledge is assessed using annual state-wide standardized tests. Schools with 'low' test scores are listed as 'failing schools' and risk losing students and funding. While teachers are required to prepare students for these standardized tests, they are at the same time encouraged to change the way science is taught to reflect how science is done, emphasizing inquiry as a way of achieving knowledge and understanding the world. Researchers and teachers can collaborate to meet their professional goals. Researchers can fulfill funding mandates and bring science process and inquiry into the classroom by sharing their research with teachers and students. Researchers who can place their work into the context of science content standards will maximize the value of their educational activities. This session will show how this can be accomplished using COSEE Great Lakes educational experiences and materials as examples.

Keywords: Education, Outreach, Standards.

STIERMAN, D.J. and KRANTZ, D.E., Department of Environmental Sciences, The University of Toledo, Toledo, OH, 43606. **Geophysical Methods for Quaternary Research and Environmental Investigations in the Great Lakes Basin.**

Geophysical measurements provide non-invasive tools for mapping geological materials and structures concealed under the earth's surface. Gravity surveys complement direct observations (drilling logs) in revealing a top of bedrock far more rugged than the low-relief surface of Lucas County. Electrical resistivity and electromagnetic ground conductivity measurements map variations in clay content in tills and sediments derived from till, although the significance of these variations was unclear until similar structures were identified in seismic profiles collected nearby in Lake Erie. Engineering firms use magnetic surveys to locate poorly documented underground storage tanks and electrical resistivity to find leachate leaking from landfills. Magnetometer surveys are used to map prehistoric and poorly documented historic sites, providing information useful in planning digs. Gravity and electromagnetic measurements were also used to map mantled karst in Sandusky and Erie Counties (Ohio), the hydro-geological feature responsible for underwater springs in Sandusky Bay. Geophysical measurements are useful in understanding a broad range of subsurface issues related to the genesis and environmental quality of our Great Lakes. *Keywords: Geophysics, Geology, Remote sensing.*

STOW, C.A., NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI. **The Saginaw Bay Multiple Stressors Project.**

The NOAA Great Lakes Environmental Research Laboratory is beginning a major field study in 2009 to examine the effects of multiple stressors on Saginaw Bay. This effort is part of a 5 year, 3.76 million dollar, multi-institutional project that includes participants from several Universities, state and federal agencies, and the private sector. The study will focus on fishery and water quality issues including walleye and yellow perch recruitment, phosphorus loading, and nuisance and harmful algal growth. Additionally, a human dimensions component of the project will explore preferences of various stakeholder groups in the Bay area. Several different modeling approaches will be used to synthesize existing and new information; these will include an updated version of one of the original models used to estimate target nutrient loads in the 1970s, as well as a Bayesian probability network (Saginaw Bayes) currently under development. This presentation will provide a project overview, to help foster coordination with other ongoing or planned projects, and so that information resulting from the project may better serve the needs of the Saginaw Bay and Great Lakes community. *Keywords: Phosphorus, Percids, Ecosystem modeling.*

STRUGER, J., RICHARDSON, V., and WATSON, S.B., Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Occurrence of Glyphosate and AMPA in Open Waters and Tributaries of Lake Erie.**

The use of glyphosate, a broad-spectrum herbicide for corn and soybean production has increased considerably in recent years in Canada and the US. Recently, it has been reported that toxic algae can potentially utilize glyphosate as a source of phosphorous. In response to concerns from the Lake Erie LAMP, glyphosate and AMPA were measured in open waters of Lake Erie and some major US tributaries in June of 2008. Thirty two water samples were collected at 1m depth at all open lake, river mouth and upstream river stations. The maximum concentration of glyphosate and AMPA were 1.72 ug/L and 0.732ug/L respectively. Glyphosate and AMPA were only detected in the tributaries and upstream stations and were not found at any open water stations. No samples exceeded the Canadian Water Quality Guideline of 65 ug/L considered protective of aquatic life. *Keywords: Glyphosate, Lake Erie, Tributaries.*

STUMPF, R.P.¹, TOMLINSON, M.C.¹, WYNNE, T.T.¹, DYBLE BRESSIE, J.², SCHWAB, D.J.², BELETSKY, D.³, and JOSEPH, S.T.⁴, ¹National Ocean Service, 1305 East-West Highway, Silver Spring, MD, 20910; ²Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108; ³Cooperative Institute for Limnology & Ecosystems Research, 4840 South State Road, Ann Arbor, MI, 48108; ⁴Michigan Sea Grant, 4840 South State Road, Ann Arbor, MI, 48108. **A Forecast System for Cyanobacterial Blooms in Western Lake Erie.**

In 2008, an attempt was made to provide near-real time nowcasts and forecasts of a cyanobacterial bloom in western Lake Erie. Experimental bulletins were released to a sample of the local research and management communities in order to evaluate the usefulness and efficiency of such forecasts. The system employed a cyanobacterial detection algorithm using remotely sensed data from the MERIS sensor on the Envisat satellite. The imagery is available

within 24-hours from the European Space Agency, and has a standard 1.2 km resolution (and an option for 300 m), with imagery collected every 2nd day. Once a bloom was detected from routine monitoring of the imagery, forecasts were possible. The location and concentration of suspected blooms were input into GNOME (General NOAA Operational Modeling Environment) along with physical forcing data in the form of forecasted currents from the Great Lakes Coastal Forecasting System (GLCFS). These simulations make it possible to forecast the movement of a suspected bloom. We detected a potential bloom of *M. aeruginosa* in early-August 2008, and were able to direct field sampling to confirm the bloom. Forecasts were produced weekly until October, when the bloom disappeared from the satellite imagery. This forecast system will be run again as a demonstration in the summer of 2009. *Keywords: Human health, Microcystis, Decision making.*

STUPPLE, G.W.¹, QIAO, S.², and BRANFIREUN, B.¹, ¹University of Toronto at Mississauga, 3359 Mississauga Rd. N., Mississauga, ON, L5L 1C6; ²China University of Geosciences, Wuhan, 430074, China. **Monitoring Atmospheric Mercury and Surface Accumulation along an Urban/Rural Gradient in Ontario, Canada.**

Policies are in place in North America designed to reduce anthropogenic mercury (Hg) emissions, however projections indicate continued increases in the global atmospheric Hg pool due to the continued rise in Hg emissions in other industrialized parts of the world. In order to support domestic regulatory action, it is desirable to demonstrate that a reduction of domestic Hg emissions will be reflected in local Hg deposition, regardless of global trends. Continuously measured speciated atmospheric Hg measurements were coupled to precipitation, and canopy vegetation accumulation of Hg at both an urban (Mississauga, ON), and rural (Dorset, ON) site in the fall of 2008. Gaseous elemental Hg (GEM) was found to be only slightly higher at the urban site on average, while particulate bound Hg (HgP) and reactive gaseous mercury (RGM) were found to be significantly higher on average at the urban site (1.3 and 2.6x, respectively). Repeated sampling of the forest canopy indicates similar overall Hg accumulation at both sites. On average, both sites demonstrate highest Hg concentrations at the top of the canopy (mean = 0.18 ng/cm²), with decreasing Hg concentrations towards the lower canopy levels (mean = 0.11 ng/cm²). At both sites, throughfall was significantly enriched in Hg relative to open field precipitation (as much as 8x). *Keywords: Mercury, Deposition, Atmospheric circulation.*

STURTEVANT, R.A., NOAA National Center for Research on Aquatic Invasive Species, 4840 South State Road, Ann Arbor, MI, 48108. **Invasive Species Information Resources.**

The Great Lakes have a long history of aquatic nonindigenous species (ANS) introductions – both intentional and unintentional. As of 2007, over 180 nonindigenous species have been reported to have reproducing populations in the Great Lakes basin, i.e. lakes Superior, Michigan, Huron, St. Clair, Erie, Ontario, and their connecting channels and water bodies within their respective drainages. This talk will provide an introduction to the numerous scientific and educational resources which are available for those seeking more information on these species. *Keywords: Invasive species, Data storage and retrieval, Education.*

SU, Y.¹, HUNG, H.¹, BRICE, K.A.¹, SU, K.¹, ALEXANDROU, N.¹, CHAN, E.¹, SVERKO, E.², and FELLIN, P.³, ¹Air Quality Research Division, 4905 Dufferin Street, Toronto, ON, M3H 5T4; ²National Laboratory for Environmental Testing, 867 Lakeshore Road, Burlington, Burlington, ON, L7R 4A6; ³AirZone One Ltd., 222 Matheson Blvd. E, Mississauga, ON, L4Z 1X1. **Air Concentrations of Polybrominated Diphenyl Ethers (PBDEs) in 2002-2004 at a Rural Site in the Great Lakes Region: Comparison to Measurements in the Arctic.**

Atmospheric PBDEs were measured on a monthly basis in 2002-2004 at Point Petre, Ontario. BDE-47, 99, and 209 were dominant congeners at this rural site in the Great Lakes. Inter-annual differences were not statistically significant, and average air concentrations were 7.0 ± 13 pg•m⁻³ for $\Sigma 14$ BDE (excluding BDE-209), and 1.8 ± 1.5 pg•m⁻³ for BDE-209. These values are comparable to reported measurements at remote/rural sites around the Great Lakes. Particle-bound percentages were greater for highly brominated congeners than less brominated ones in the same temperature ranges; and that of less brominated congeners (e.g., BDE-47) increased along with decreasing ambient temperatures. The observed gas/particle partitioning behaviour is consistent with laboratory measurements, and fits well to the Junge-Pankow model. Weak temperature dependence of gaseous species further suggests that advective inputs likely maintained air concentrations at Point Petre. Continuous air measurements at the Arctic site of Alert show similar congener profiles and comparable concentrations as those at Point Petre. However, differences are found at Alert as well: strong seasonality of less brominated congeners may indicate potential volatilization emissions locally or regionally; and increasing inter-annual tendencies imply ongoing PBDE emissions globally. *Keywords: PBDEs, Great Lakes basin, Arctic.*

SWARTZ, K., American Rivers, 348 S. Erie Street, Toledo, OH, 43604. **Green Stormwater Management in the Great Lakes: Toledo Case Study for Building Successful Community Stormwater Projects.**

American Rivers' Catching the Rain initiative seeks to educate developers, local governments, and local partners about stormwater management techniques that reduce stormwater runoff. Techniques include permeable paving, green roofs, rain barrels and rain gardens, which beautify communities, reduce impervious surfaces and increase stormwater infiltration into the ground, thus reducing pollutants that would otherwise flow into rivers and streams. Over the past year, American Rivers has extended its Great Lakes work to the City of Toledo. From our field office in Toledo; we conducted outreach and education on stormwater pollution and the benefits of rain gardens. We reached out to local elected officials, educators, master gardeners, senior citizens, and homeowners to educate them about the overall effectiveness of onsite infiltration. We organized green infrastructure tours to show local officials effective natural stormwater management techniques in other Great Lakes communities. We are also helping local schools develop curriculum to use in their outside learning laboratories. In addition, we have been particularly involved with building a rain garden initiative with the City of Toledo. *Keywords: Watersheds, Ecosystems, Management.*

SWINEHART, C.Y.¹ and FINNELL, E.H.¹, ¹Michigan Sea Grant, 334 Natural Resources Bldg., East Lansing, MI, 48824-1222; ²Michigan Office of the Great Lakes, 525 W. Allegan St., Lansing, MI, 48933. **PILOTING A VOLUNTEER AIS MONITORING PROGRAM: Michigan's Experience with Clean Boats, Clean Waters.**

In 2006 and 2007, Michigan Sea Grant piloted Clean Boats, Clean Waters, a volunteer AIS monitoring program which it adapted and streamlined from the original developed by Wisconsin Extension and Department of Natural Resources. This program trains volunteers to present aquatic invasive species (AIS) information to boaters at launch sites and to demonstrate the proper inspection and cleaning of recreational watercraft to prevent the introduction and spread of AIS to previously uninfested bodies of water. In its first two years, Michigan Sea Grant and Michigan Office of the Great Lakes representatives developed materials, conducted seven training workshops and facilitated the formation of several volunteer teams, which conducted the program in a variety of ways and reached thousands of boaters. Other organizations within and from outside the state have expressed interest in using the program as a model. This presentation will describe the program, its outcomes and lessons learned. *Keywords: Education, Environmental education, Invasive species.*

TERTULIANI, J.S.¹, ALVAREZ, D.A.², FURLONG, E.T.³, MEYER, M.T.⁴, ZAUGG, S.D.³, and KOLTUN, G.F.¹, ¹Ohio Water Science Center, 6480 Doubletree Avenue, Columbus, OH, 43229; ²Columbia Environmental Research Center, 4200 New Haven Road, Columbia, MO, 65201; ³National Water Quality Laboratory, Building 95, Mail Stop 407, Denver, CO, 80225-0046; ⁴Organic Geochemistry Research Laboratory, 4821 Quail Crest Place, Lawrence, KS, 66049. **Occurrence of Organic Wastewater Compounds in Tributaries to the Cuyahoga River, Northeast Ohio.**

The U.S. Geological Survey, in cooperation with local and state agencies, measured occurrence and distribution of organic wastewater compounds in an urban watershed in northeast Ohio through use of passive sampling. For 28 days in May–June 2006, canisters containing a polar organic integrative sampler (POCIS) and a semipermeable membrane device (SPMD) were deployed and downstream from seven wastewater-treatment-plant (WWTP) outfalls in the Tinkers Creek watershed, at a site downstream from all WWTP discharges, and at two reference sites in nearby tributaries to the Cuyahoga River. Streambed-sediment samples also were collected at each site when the canisters were retrieved. Twelve antibiotic, 20 pharmaceutical, 41 wastewater, and 22 hydrophobic compounds were detected in water at one or more sites. With the exception of hydrophobic compounds, it was common at most sites to have more compounds detected in POCIS samples collected downstream from WWTP outfalls than in corresponding samples collected upstream from the outfalls. In contrast, 15 wastewater compounds (two of which are known or suspected endocrine disruptors) were detected in sediments at all sites in the Tinkers Creek watershed, irrespective of whether the site was upstream or downstream from a WWTP. *Keywords: Water quality, Endocrine disruption, SPMDs.*

THOMAS, M.K. and LITCHMAN, E., 3700 E Gull Lake Dr, Kellogg Biological Station, Hickory Corners, MI, 49060. **Growth Responses of Invasive and Native Cyanobacteria to Temperature.**

C. raciborskii is a toxic invasive species that is believed to have spread from the tropics & subtropics to colonize temperate water bodies in Europe & North America in recent decades. Previous research has suggested that wide physiological tolerances and adaptation to local conditions have aided in this spread. We examined three American strains of *C. raciborskii*, one northern and two southern, for growth rates at a range of temperatures (15 - 40°C, 5° intervals). We show significant differences in optimal temperature for growth between strains, as estimated using an existing growth model. Growth curves also differed and temperature optima were lower when the strains were grown in the absence of nitrogen. These parameter estimates indicate that adaptation to local conditions is likely to be an important factor for *C. raciborskii*'s spread, and allow us to better model the future pattern of spread. Several strains of *Microcystis* from Michigan showed lower optimum temperatures for growth, suggesting that warming climate may preferentially select for invasive cyanobacteria. *Keywords: Cyanophyta, Global warming, Invasive species.*

THOMPSON, T.A.¹, LEPPER, K.², BAEDKE, S.J.³, ARGYILAN, E.P.⁴, and WILCOX, D.A.⁵,
¹Indiana Geological Survey, Indiana University, 611 North Walnut Grove, Bloomington, IN, 47405-2208; ²Optical Dating and Dosimetry Lab, North Dakota State University, Dept. of Geosciences, 218 Stevens Hall, Fargo, ND, 58105; ³Dept. of Geology and Env. Sciences, James Madison University, Msc 6903, Harrisonburg, VA, 22807; ⁴Dept. of Geosciences, Indiana University Northwest, 3400 Broadway, Gary, IN, 46408; ⁵Dept. of Env. Science & Biology, SUNY-Brockport, 350 New Campus Drive, Brockport, NY, 14420. **Strandplain Evidence for Late Holocene Lake Level and Isostatic Rebound in the Lake Huron Basin.**

Strandplains of beach ridges occur in late Holocene embayments along upper Great Lakes coastlines. The beach ridges form during highstands; and internally, they contain sedimentologic data that record the elevation of the lake through time. The relative lake-level hydrograph that can be produced from these data can be used to interpret long-term lake-level change and GIA for a given strandplain. By combining data from multiple sites and interactively stripping off GIA from each relative hydrograph, a late Holocene hydrograph for the lake basin at its outlet can be created. Four sites were studied along the Lake Huron shoreline: Negwegon State Park and Mackinaw State Forest south of Alpena, Michigan; Saint Vitals Bay at the eastern tip of the upper peninsula of Michigan; and Albert Sleeper State Park at the northern tip of the thumb of the lower peninsula of Michigan. Approximately 240 vibracores were collected and processed. Basal foreshore elevations were determined from sedimentary structures in core and peel and grain-size distributions. Approximately 60 samples of dune crest sediments were collected, and OSL age determinations were made on these samples. The foreshore elevation and OSL data were combined to produce four relative lake-level hydrographs that illustrate lake level and GIA to about 4900 calendar year B.P. *Keywords: Lake Huron, Holocene, Water level fluctuations.*

TLOCZYNSKI, K. and WOLIN, J.A., Dept. of Bio. Geo. & Environ. Science, 2121 Euclid Ave., Cleveland State University, Cleveland, OH, 44115. **Urbanization and Wetland Soil Phosphorus Retention in the Cuyahoga River Watershed.**

Phosphorus concentrations in the Cuyahoga River have increased since 1995 though mechanisms behind this are not well understood. Wetland phosphorus retention is affected by urbanization via increased nutrient loads, impervious surfaces, habitat degradation and wetland loss. Wetland soil phosphorus retention is finite. High phosphorus inputs and wetland loss may alter the capacity of urban wetland soils to retain phosphorus. We sampled 12 wetlands in the Cuyahoga watershed across varying levels of urbanization to determine the phosphorus retention capacity of their soils. Six cores were obtained from spatially distributed random sites in each wetland. Soils were tested for phosphorus sorption and desorption, soil moisture, and loss-on-ignition. Urbanization was quantified using % impervious surface in a 250m buffer around each wetland as determined from the 2001 National Land Cover Database in ArcGIS. Results show a significant decrease in PO₄ sorption in wetland soils with decreased saturation, and impervious surface cover. Wetland soil moisture showed a significant decline with increasing urbanization. Results indicate that wetlands in urban areas retain less PO₄ than wetlands in more rural regions of the Cuyahoga watershed, and that urbanization most likely has resulted in a decrease in wetland soil phosphorus retention. *Keywords: Wetlands, Urban watersheds, Phosphorus.*

TOMASALLO, C.D., ANDERSON, H.A., HAUGHWOUT, M., IMM, P., and KNOBELOCH, L.M., Wisconsin Division of Public Health, 1 W. Wilson Street, Room 150, Madison, WI, 53702. **Cardiovascular Mortality among Frequent Consumers of Great Lakes Sport Fish.**

Commercial and sport-caught fish provide a healthy source of dietary protein, omega-3 fatty acids, and other micro-nutrients. Regular fish consumption has been associated with a decreased risk of heart disease and health professionals encourage adults to include fish in their weekly diets. However, fish harvested from contaminated waters can contain higher levels of persistent, bioaccumulative chemicals such as PCBs, dieldrin, DDT. Predatory fish can also be high in methylmercury. Characteristics of this cohort allowed us to evaluate the interactive effects of fish intake and contaminants found in Great Lakes fish on human mortality. Causes of mortality were obtained for 3,847 frequent and infrequent Great Lakes sport fish consumers who were followed 1995-2006. Analysis of age-adjusted, cause-specific death rates confirmed a protective effect of total fish intake against cardiovascular disease mortality among men in the referent (infrequent Great Lakes sport fish consumer) population. However, among consumers of Great Lakes sport fish, ingestion of 13 to 103 fish servings a year was protective against cardiovascular disease mortality, but this beneficial effect was not seen at higher ingestion rates. Continued monitoring of this cohort will provide better insights into the effect of sport fish intake on human mortality. *Keywords: Sport Fish Consumption, Great Lakes, Environmental contaminants.*

TOMLINSON, L.M. and AUER, M.T., 1400 Townsend Dr., Houghton, MI, 49931. **Nutrient Management and the Great Lakes *Cladophora* Model.**

Phosphorus is the appropriate focus for management of nuisance growth of *Cladophora* as it is the growth limiting nutrient for this alga. Here, we utilize the Great Lakes *Cladophora* Model (GLCM), a mechanistic model which reflects current understandings of *Cladophora* ecology and can be used as a management tool guiding nutrient management in the nearshore. We present relationships between the nutrient forcing condition (soluble reactive phosphorus) and both *Cladophora* biomass and production, as a reasonable first step in developing management guidelines. We utilize model-calculated *Cladophora* production under nutrient-saturated conditions as the benchmark for nuisance conditions, examining reductions in biomass and normalized production corresponding to reductions in phosphorus availability. The GLCM is then applied to identify reductions from the contemporary case achieved at various soluble reactive phosphorus levels. Net *Cladophora* production was calculated for the region of optimal growth over the period of maximum production. Model output described the relationships between the soluble reactive phosphorus concentration and internal phosphorus levels, *Cladophora* biomass and *Cladophora* production. *Keywords: Mathematical models, Management, Cladophora.*

TORBICK, N.M.¹ and KRAUSE, A.E.², ¹Applied Geosolutions, Newmarket, NH; ²University of Toledo, Toledo, OH. **Improving Freshwater Ecosystem Services in Social-Ecological Systems through the Integration of Remote Sensing and Geospatial Data.**

The sustainability of freshwater ecosystem services provided by social-ecological systems has been highlighted by the United Nations in its Millennium Ecosystem Assessment report. The society in the Laurentian Great Lakes has a tremendous responsibility for maintaining 20% of the world's surface freshwater. Land use in the basin directly affects the water quantity and quality that helps to supply the water in the Great Lakes. Because land-use decision making often occur at a local municipal level, we are developing methodology to quantify landscape networks at the same scale. Our case study for developing the methodology is the Maumee River Watershed (MRW), which drains into Lake Erie and is the largest watershed in the Great Lakes. We used Landsat-based National Land Cover Data (NLCD) to divide the watershed into appropriately scaled watershed units. Custom Python scripts and geoprocessing transform each land use land cover patch into a node within the network. Nodes are connected based on amount of shared borders. On this base framework, we can then overlay the flow of water across the landscape to determine the importance landscape functional diversity for providing freshwater ecosystem services. This method improves on current landscape methodology for quantifying diversity. *Keywords: Coastal ecosystems, Lake Erie, Remote sensing.*

TRAMER, E.J., Department of Environmental Sciences, University of Toledo, Toledo, OH, 43606-3390, United States. **Developing an Environmental Sciences Curriculum: A Case Study at the University of Toledo.**

One of the greatest challenges faced by environmental professionals is gaining sufficient breadth of training to address typically multidisciplinary, environmental problems. Ironically, developing a university curriculum in environmental sciences faces a similar obstacle balancing

adequate disciplinary depth with necessary multidisciplinary breadth. In 1994, the University of Toledo charged a task force of 30 faculty members, from 13 departments in 5 colleges, to develop such a program. They began with a shared philosophical belief that solving environmental problems requires the integration of sociological, scientific and technological tools. A two-track interdisciplinary program was created: the BS in Environmental Sciences and the BA in Environmental Studies. Both degrees require basic courses in math, chemistry, geology, biology, political science, philosophy, economics and planning. Both require an area of concentration within a particular discipline (e.g., chemistry, political science), and serving 100 hours as an intern. The key to the success of this program is the practical experience of the intern requirement, the flexibility in choosing an area of concentration, and the availability of core classes in natural sciences, humanities and social sciences that jointly meet degree, college and university requirements. *Keywords: Education, Curriculum, Jobs.*

TURYK, M.E., University of Illinois at Chicago, School of Public Health, 1603 W. Taylor Street, Room 879, Chicago, IL, 60612. **Sport Fish and Commercial Fish Consumption in Residents of the Great Lakes Basin.**

Studies of sport fish and commercial fish consumption by populations in the Great Lakes basin were reviewed. Overall, 80-90% of adult residents consumed fish, 10-30% consumed sport caught fish, and 7-8% consumed Great Lakes sport caught fish (GLSCF). Commonly consumed GLSCF included perch, smelt, walleye, rainbow trout, Chinook salmon, coho salmon, lake trout, brown trout, and carp/catfish, while commonly consumed commercial fish included tuna, shrimp, cod, salmon, clams, and catfish. Gender differences were not generally noted for commercial fish consumption, but men consumed more GLSCF than women. Fish consumption was higher in persons of Asian ethnicity. Sport fish consumption by children was related to their parents' sport fish consumption levels. Pregnant women in the Great Lakes basin consumed fish and sport fish at rates similar to other surveyed groups, although one study found a significant decrease in fish consumption during pregnancy compared with prior to pregnancy. When available, trends in longitudinal angler cohorts suggest decreases in GLSCF consumption, but not total fish consumption, and population based surveys do not support decreases in overall fish consumption through the early 2000's. *Keywords: Fish, Human health, Environmental health.*

TWISS, M.R.¹, ULRICH, C.¹, ZASTEPA, A.², and PICK, F.R.², ¹Department of Biology, Clarkson University, Potsdam, NY, 13699; ²Department of Biology, University of Ottawa, Ottawa, ON, K1N 6N5. **Assessment of Phytoplankton Growth and Grazing Rates in Lake Ontario, July 2008.**

We measured growth and grazing rates of phytoplankton at nine stations from the epilimnion and metalimnion, the latter which contained Deep Chlorophyll Maxima. Dilution assays (100-8% lakewater) used both size fractionated chl-a (microplankton, 20-153 µm; nanoplankton, 2-20 µm; picoplankton, 0.2-2 µm) and PE-rich Cyanobacteria measured by flow cytometry as endpoints. In addition, antibiotic assays were conducted as independent measures of PE-rich Cyanobacteria growth and grazing. Phytoplankton was dominated by Heterokontophyta & Dinophyta (69-98% of in situ chl-a) with PE-rich Cyanobacteria and

Cryptophyta comprising additional important contributions to the DCM, as determined using a FluoroProbe. Total chl-a ranged from 2.1-5.8 µg/L with size fractions (% total) ranging from: microplankton, 15-36%; nanoplankton, 29-63%; and picoplankton, 18-56%. Total chl-a specific growth rates ranged from 0.14-2.01 per day whereas grazing rates were higher 0.22-2.42 per day; this was the case for all size fractions. However, PE-rich Cyanobacteria had a growth rate (1.23 per day) that was nearly double the grazing rate (0.70 per day) suggesting that either non-PE-rich Cyanobacteria comprised the greatest loss in the picoplankton or that the size fractionated assay was affected by chl-a changes not related to growth or grazing. *Keywords: Zooplankton, Lake Ontario, Phytoplankton, Microzooplankton.*

TYLER, J.A.¹, RUTHERFORD, E.S.², WILEY, M.J.³, RISENG, C.M.³, PIJANOWSKI, B.C.⁴, and HYNDMAN, D.⁵, ¹Fisheries Projections, Farmington, CT, 6032; ²NOAA - Great Lakes Environmental Laboratory, Ann Arbor, MI, 48108; ³University of Michigan, Ann Arbor, MI, 48109; ⁴Purdue University, West Lafayette, IN, 47907; ⁵Michigan State University, East Lansing, 48824. **Effects of Urban Development in the Muskegon River Watershed on Growth, Survival and Potential Recruitment of a Lake Michigan Steelhead Population: Results of a Multi-Modeling Approach.**

We examine how rates of urban development and reforestation in the Muskegon River watershed affect age-0 steelhead populations with a multi-modeling system. Basin-wide land use change and hydrologic models forecast alterations in the ecosystem's water budget. Local-reach hydraulic models provide a high-resolution, spatially-explicit depiction of the physical environment that we combine with site-specific data to model the biological environment. Our individual-based model (IBM) operates in this model environment and follows steelhead from spawning until the end of the first growing season in early October. The IBM includes mechanistic submodels which simulate steelhead foraging, growth, movement, and mortality resulting from predation, starvation, and substrate alteration. We run the IBM for landscapes representing years 1998, 2010, 2020, 2040, 2070 and 2100 under land use scenarios reflecting: 1) expected urban development (baseline), 2) urban development under a 'slow growth' regime, and 3) baseline with reforestation. IBM simulations show changes in survival, density, size and potential recruitment of age-0 steelhead under the three different urban development scenarios. *Keywords: Model studies, Watersheds, Fish populations.*

URBAN, N.R.¹, PERLINGER, J.A.¹, MWANGI, J.M.¹, MCDONALD, C.P.¹, MCKINLEY, G.A.², DESAI, A.², ATILLA, N.², and BENNINGTON, V.², ¹Dept. Civil & Environmental Engineering, Michigan Technological University, Houghton, MI, 49931, USA; ²Atmospheric and Oceanic Sciences, University of Wisconsin - Madison, Madison, WI, 53706, USA. **Field Measurements of CO₂ in and above the Great Lakes: the Case for Net Emission of CO₂.**

Mass balance studies, stable isotope measurements, and rates of respiration and photosynthesis indicate that Lake Superior is a net source of CO₂ to the atmosphere. Recent modeling of carbon cycling suggests that the lake is a net sink for atmospheric CO₂ in summer and only a weak source for the remainder of the year. In this talk, we review evidence for net emissions and try to reconcile the disagreement with the modeling study. All Laurentian Great

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Lakes are supersaturated with respect to atmospheric CO₂, but supersaturation is least for Lake Superior. Previous mass balance studies have overestimated the degree of supersaturation and gas-exchange fluxes. Recent measurements show elevated CO₂ above the lake relative to over land. Spatial and temporal variability in the difference between air and water pCO₂ are not well known, although this difference is essential for all estimates of air-water exchange. Short-term CO₂ fluxes estimated from simultaneous measurements of pCO₂ in and above the lake and eddy covariance measurements are 10-fold higher than current model predictions. CO₂ emissions are also compared with rates of photosynthesis and microbial growth to assess the controls on emission rates. While not all differences can yet be explained, this comparison shows the need for both modeling and other approaches. *Keywords: Carbon cycle, Air-water interfaces, Biogeochemistry.*

VAIL, J.H. and WEINERT, M.E., GVSU Annis Water Resources Institute, 740 W. Shoreline Drive, Muskegon, MI, 49441. **Examining Lake Monitoring Data from a Vessel-based Education Program – Can the Data be Useful?**

The Annis Water Resources Institute (AWRI) at Grand Valley State University has operated research and education vessels since the 1960s. Students in grades 4-12 participate in hands-on water monitoring aboard its two specially designed vessels. AWRI has water quality data sets that students have generated dating back to 1986. They are from sites in Lake Michigan near Grand Haven and Muskegon, Michigan as well as in Spring Lake and Muskegon Lake, Michigan. Parameters in the data sets include dissolved oxygen, water temperature, pH, conductivity, turbidity, benthic faunal composition, transparency, and color (Forel-Ule). Global change and invasive species have prompted a closer look at these data sets to ascertain trends and correlations with published research. Our premise is that informal monitoring efforts can be of value to researchers looking for supplemental information; however, the methods used to collect and analyze samples must be scrutinized carefully to ensure the data meet appropriate QA/QC standards. *Keywords: Education, Water quality, Outreach.*

VALIANTE, M., 401 Sunset Ave., Windsor, ON, N9B 3P4. **The Impact of the Great Lakes Compact on the Development of Canadian Water Law.**

The historic Great Lakes Compact is now in force in the United States, and states are taking steps to implement it. The Compact does not include Ontario and Quebec, but they are signatories of the companion Agreement, negotiated at the same time. Both Ontario and Quebec were active participants in the negotiation of the Agreement and how these Canadian jurisdictions respond through legislative and policy changes will have a direct impact on the success of the entire regime. Although the Agreement is not, in the sense of the Compact, a legally binding agreement, nevertheless, both provinces have taken steps to implement the commitments they made. This paper will explore the changes that are being taken in both provinces, and reflect on the influence the Compact and Agreement will have on the evolution of water law in the two jurisdictions, one a common law jurisdiction with a long history of water taking regulation, and one a civil law jurisdiction. *Keywords: Policy making, Legislation, Great Lakes basin.*

VAN DIJK, D., Geology, Geography & Env. Studies, Calvin College, 3201 Burton St SE, Grand Rapids, MI, 49546. **Lake Michigan Foredune Evolution and Short-Term Variations in Lake Level, Weather and Vegetation.**

The geomorphic history of Great Lakes coastal dunes includes long-term trends and short-term variations. This study explores the seasonal to interannual patterns of change as a Lake Michigan foredune responds to variations in lake level, weather and vegetation. The study site is an active foredune in P.J. Hoffmaster State Park on the east coast of Lake Michigan. Foredune changes, local conditions and processes have been monitored since October 2000 with repeated ground surveys, erosion pins, microclimate measurements and observations of surface conditions. Additional weather and lake level data were obtained from regional sources. Study results show a trend of foredune growth during the study period, with seasonal and interannual variations in the rates and spatial patterns of dune growth. Changes in the volumes of sand added to the foredune ($2-5 \text{ m}^3 \text{ m}^{-1} \text{ yr}^{-1}$) reflect the variability of sediment inputs which are primarily controlled by lake level, beach surface conditions and wind patterns. Interactions between the changing foredune topography, vegetation and sediment inputs produce different spatial patterns of foredune growth. Understanding the causes and patterns of short-term variability in dune evolution is an important component of understanding the geomorphic history of coastal dune system. *Keywords: Lake Michigan, Geomorphology, Coastal dunes.*

VAN VLIET, D.J.¹, MARTIN, P.J.¹, MEYER, P.¹, BRADFORD, A.², WALKER, R.⁴, MORTSCH, L.³, BATES, S.⁵, GARRAWAY, M.⁵, MULCHANSINGH, K.⁶, and TUPLING, J.⁷,
¹AquaResource Inc., Breslau, ON; ²University of Guelph, Guelph, ON; ³Environment Canada, Waterloo, ON; ⁴EBnFLO Environmental, Waterloo; ⁵Ministry of Natural Resources, Peterborough, ON; ⁶Credit Valley Conservation, Mississauga, ON; ⁷Town of Orangeville, Orangeville, ON. **Water Quantity Risk Assessments in Ontario: A Great Lakes Headwaters Pilot Project.**

The Province of Ontario has recently passed the Clean Water Act (2006) and is currently completing technical studies to protect the quality and quantity of the Province's drinking water sources. Under the Act, Ontario municipalities will complete Water Quantity Risk Assessments to identify threats to the quantity of their water sources. These assessments must consider the influences of competing water users, land development, and climate change on drinking water supplies and ecological requirements. The Ontario Ministry of Natural Resources is completing a Pilot Project for the Water Quantity Risk Assessments for the Town of Orangeville. The Town relies solely on groundwater supplies and is located in the headwaters of four major river systems, including Nottawasaga (Lake Huron), the Credit and the Humber (Lake Ontario), and the Grand (Lake Erie). The project's evaluation of future groundwater takings relies on the integration of some of the latest scientific advancements including Ecological Flow Requirements Research at the University of Guelph and Climate Change Assessment expertise at Environment Canada. The results of the Pilot Project are currently being incorporated into educational materials that will be used to guide similar studies for municipalities across the Province. *Keywords: Drinking water, Hydrologic budget, Climate change.*

VANDERPLOEG, H.A.¹, POTHOVEN, S.A.², FAHNENSTIEL, G.L.², NALEPA, T.F.¹, CAVALETTO, J.F.¹, LIEBIG, J.R.¹, STOW, C.A.¹, and MADENJIAN, C.P.³, ¹Great Lakes Environmental Research Laboratory, NOAA, 4840 S. State Road, Ann Arbor, MI, 48108; ²Lake Michigan Field Station, GLERL, 1431 Beach Street, Muskegon, MI, 49441; ³Great Lakes Science Center, USGS, 1451 Green Road, Ann Arbor, MI, 48105. **Signals in the Plankton: Impact of Weather and Non-Indigenous Species on Seasonal, Interannual, and Long-Term Trends on Plankton Dynamics in Lake Michigan.**

Systems theory, or common sense, tells us that to understand a system you have to observe it as it changes. Our long-term seasonal data set on zooplankton, chlorophyll, nutrients, and mussels collected at nearshore and offshore stations near Muskegon, Michigan, provides us with a system undergoing massive changes. The changes themselves and experimental work on dreissenid filtering showed that interannual variability in weather and mussels were important drivers of change. However, long-term seasonal trends in nutrients and chlorophyll that preceded mussel population expansion suggests that changes in nutrient loading or internal recycling may have been an important driver of change. *Keywords: Ecosystem forecasting, Lake Michigan, Dreissena.*

VENIER, M.¹, WIERDA, M.², BOWERMAN, W.², and HITES, R.A.¹, ¹School of Public and Environmental Affairs - Indiana University, 1005 E. 10th street, Bloomington, IN, 47401; ²Dept. of Forestry & Natural Resources - Clemson University, 261 Lehotsky Hall, Clemson, SC, 29634. **Flame Retardants in Plasma Samples from Bald Eagles from the Great Lakes Region.**

In order to assess contamination of higher trophic level organisms, plasma samples were collected from bald eagles at several locations in the Great Lakes region in 2005. The chemicals investigated included polybrominated diphenyl ethers (PBDEs), as well as the emerging flame retardants hexabromocyclododecane (HBCD), Dechlorane Plus, 1,2-bis(2,4,6-tribromophenoxy)ethane (TBE), and decabromodiphenyl ethane (DBDPE). The measured concentrations of these flame retardants will be presented and compared to those previously obtained from other birds from the Great lakes region. BDE-47, 99, and 100 were the most abundant congeners in all samples, accounting for ~70% of total PBDEs. Other lower brominated congeners such as BDE-28, 49, 153, and 154 were also detected in all of the samples. The higher brominated congeners, such as nona-BDE and deca-BDE were detected only in a few samples. This observation might be due to the low bioavailability of the higher brominated compounds or to rapid loss from the environment. The two conformers of Dechlorane Plus were detected in several samples, but TBE, HBCD, and DBDPE were never detected. Little correlation between the levels of PBDEs and PCBs and organochlorine pesticides was observed, probably because of the relatively small number of samples analyzed. *Keywords: Toxic substances, PBDEs, Biomonitoring.*

VERHAMME, E.M., DEPINTO, J.V., and REDDER, T.R., LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48103. **Development of a Linked Fine-Scale Hydrodynamic and Ecosystem Model for Assessing the Impact of Multiple Stressors in 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. More recently we have been developing models aimed at simulating the system's response to stressor interactions. We have modeled the combined impacts of phosphorus loadings and dreissenid filtering on the reoccurrence of *Microcystis* blooms (SAGEM). As part of a NOAA funded project we have been refining our previous model with the development of SAGEM2. One of the primary advances in SAGEM2 is the coupling of the existing lower food web framework with the new Great Lakes *Cladophora* Model (GLCM) developed by M. Auer and others. Another refinement has been linking SAGEM2 to a fine-scale (2 km) hydrodynamic model (EFDC) at the same resolution. Initial testing of the model has focused on the early 1990's, covering a period of intense data collection. The model will eventually be used in conjunction with a watershed model and a bioenergetics model of yellow perch and walleye to assist water quality and fishery managers in making informed management decisions for the system. *Keywords: Saginaw Bay, Model studies, Eutrophication.*

VERHOUGSTRAETE, M.P. and ROSE, J.B., Michigan State University, 13 Natural Resources, East Lansing, MI, 48824-1222. **Recreational Water Quality Assessment of Saginaw Bay Beaches Using Fecal Indicator Bacteria and Source Tracking Methods on Samples from Shallow and Deep Waters, Sediment, and Muck.**

Saginaw Bay, located on Michigan's eastern shore, is populated with 43 public beaches. Beach monitoring data indicated over 50% of these beaches have had at least 1 beach closure since 2000 but only 10% were due to a known source of pollution. Our lab investigated 4 Saginaw Bay beaches (WB, BC, CC, and PC) to identify possible sources of fecal contamination, identify environmental parameters relationships to microbial levels, and determine if the muck/sediment is impacting surrounding water quality. Samples (n=86) were taken from the shallow (15 cm) and deep (90 cm) water, algal masses in nearshore (muck), and sediment. The highest microbial averages (enterococci 1.16×10^5 CFU/g wet weight) were detected in the muck of BC. Correlations detected microbial levels at each beach responded uniquely to environmental conditions with BC strongly linked to rainfall, WB influenced by wind and wave action, and the other 2 beaches impacted greatest by water/air temperatures and wind speed. Muck and sediment were found to have limited impact on the water quality of waist deep waters. Bacteroides and the esp gene source tracking markers indicated the presence of bovine and human fecal contamination to Saginaw Bay. Potential sources of pollution not detected through routine beach monitoring were identified for these 4 beaches. *Keywords: Water quality, Microbiological studies, Lake Huron.*

VILLENEUVE, M.J., 351 boulevard Saint-Joseph, place Vincent Massey, 7ième étage, Gatineau, QC, K1A 0H3. **The Canadian Water Availability Indicators Initiative: Great Lakes Pilot.**

The sustainability of freshwater supplies is a growing concern worldwide. Even in Canada, a country relatively rich in fresh water resources, pressures including rapid urbanization, industrial expansion, agricultural intensification, and the potential impacts of climate change stress water supply and jeopardize the health of aquatic ecosystems. In response to this, Environment Canada has started an initiative to develop water availability indicators. The Water Availability Indicators Initiative is a suite of indicators that provides an assessment of the state of water resources in Canada via measures of the amount of surface water available, the ratio of water use to water available, an overview of groundwater data availability, measures of ecological demand for water and more. These indicators are intended to educate the Canadian public as well as water resource policy and decision makers and other interested groups. The indicators are intended to be applicable at a national and regional scale, be scientifically sound and use currently available data. Nine indicators have been selected to describe the current fresh water situation in Canada. The Great Lakes Region has been used as one of the pilot areas in the initiative. *Keywords: Indicators, Water availability, GIS.*

VINCENT, R.K., Department of Geology, School of Earth, Environment, and Society, Bowling Green, OH, 43403-0211, US. **The 2008 Cyanobacteria Bloom in the Western Basin of Lake Erie as Monitored by LANDSAT TM.**

An algorithm for mapping phycocyanin content (PC) in lake water from LANDSAT TM satellite data was derived in the past from Western Lake Erie data for July 1, 2000, and found to be robust when applied to a withheld LANDSAT TM and in situ water sample data set for September 27, 2000. This same algorithm was applied to LANDSAT 7 data of Path 20 Row 31 (Toledo Frame) in Western Lake Erie on overpass dates with less than 30% cloud cover for the study period of June to October, 2008. The results show a large cyanobacteria bloom in September - October of 2008, and its precursor. The algorithm works for regions of the imaged area where the phycocyanin content (PC) falls in the range of 2-20 ppb (micrograms/liter), which occur on the edges of the large bloom. Another LANDSAT TM algorithm has been derived for the high-bloom version, where $PC > 20$ ppb. A contrast-stretched natural color LANDSAT TM image can easily be used to highlight these high bloom areas with a green coloration, though the latter is not specific to PC versus Chlorophyll a. This research was funded by NOAA Grant NA06OAR4600197. *Keywords: Cyanophyta, Lake Erie, Remote sensing.*

WALLAT, G.K., OSU South Centers, 1864 Shyville Road, Piketon, OH, 45661. **Impacts of VHS on the Ohio Aquaculture Industry.**

The detection of the new type IV-B strain of viral hemorrhagic septicemia in the Great Lakes in 2005 and its rapid spread through most of the Great Lakes water bodies prompted the USDA's Animal and Plant Health Inspection Service to initiate a Federal Order in 2006 to restrict interstate movement of fish from the Great Lakes states. Many state resource agencies in

the Great Lakes region followed suite with additional regulations on receiving fish in their respective states. Although VHS type IV-B has not been detected in aquaculture facilities in the Great Lakes states, producers continue to meet a myriad of differing testing requirements and regulations to move fish interstate, with significant additional costs to their operations. A review of how these regulations and policies have affected Ohio aquaculture producers and efforts by Ohio aquaculture producers, state agencies and APHIS to work together on these issues will be presented. *Keywords: Aquaculture, VHS.*

WANG, J.¹, BAI, X.², and CLITES, A.¹, ¹NOAA GLERL, 4840 South State Road, Ann Arbor, MI, 48108; ²University of Michigan CILER, 4840 South State Road, Ann Arbor, MI, 48108.

Seasonal, Interannual, and Spatial Variability of the Great Lakes Ice Cover.

Seasonal and interannual variability of lake ice cover in the Great Lakes is investigated using historical and satellite measurements for the period 1962-2008. After climatology of the seasonal cycle is derived, large anomalous interannual variability is found in response to atmospheric teleconnection patterns. Nevertheless, spatial variability of ice cover in the five Great Lakes shows regional features. A principal-component or EOF (empirical orthogonal function) analysis is applied to lake ice anomalies to derive major spatial and temporal patterns, which can be explained by major atmospheric variability controlled by well-known climate patterns: Arctic Oscillation (AO) and ENSO (El Nino and Southern Oscillation). Thus, a normalized ice anomaly index is derived by combined five Great Lakes ice normalized by its individual standard deviation, which can be used to be regressed atmospheric forcing field. Lake ice reduction rate over the last three decades in each lake is estimated. Dynamic mechanisms controlling lake ice temporal and spatial variability are investigated in the context of regional climate changes. *Keywords: Climate change, Ice, Global warming.*

WANG, J.¹ and BAI, X.², ¹NOAA GLERL, 4840 South State Road, Ann Arbor, MI, 48108; ²University of Michigan CILER, 4840 South State Road, Ann Arbor, MI, 48108. **Is the Dipole Anomaly a Major Driver to Record Lows in Arctic Summer Sea Ice Extent?**

Recent record lows of Arctic summer sea ice extent are found to be triggered by the Arctic atmospheric Dipole Anomaly (DA) pattern. This local, second-leading mode of sea-level pressure (SLP) anomaly in the Arctic produced a strong meridional wind anomaly that drove more sea ice out of the Arctic Ocean from the western to the eastern Arctic into the northern Atlantic during the summers of 1995, 1999, 2002, 2005, and 2007. In the 2007 summer, the DA also enhanced anomalous oceanic heat flux into the Arctic Ocean via Bering Strait, which accelerated bottom and lateral melting of sea ice and amplified the ice-albedo feedback. A coupled ice-ocean model was used to confirm the historical record lows of summer sea ice extent. *Keywords: Arctic, Climate change, Ice.*

WANG, Y. and JANSSEN, J., WATER Inst., UW-Milwaukee, 600 East Greenfield Ave., Milwaukee, WI, 53204. **Larval Deepwater Sculpin Density and Growth in Relation to Spring Thermal Bar Dynamics.**

We assessed the relative density of larval deepwater sculpin (*Myoxocephalus thompsoni*) offshore vs. inshore of the 4° C isotherm (thermal bar) during Lake Michigan's spring warm-up. Samples were collected via Tucker trawl at pairs of stations inshore and offshore of the thermal bar at several dates in 2007 and 2008. The adult deepwater sculpin is a cold-water and bottom-dwelling fish that lives and spawns deeper than about 70 m. Larval deepwater sculpin hatch in offshore deep water and become pelagic. We found greater densities of larval deepwater sculpin inshore of the thermal bar and the size of larvae was also larger inshore. We propose that these observations are not due to migration of larvae toward inshore water. Instead, larval survival and growth are likely greater shoreward of the thermal bar because of the warmer temperature and greater food abundance. However, the nearshore larvae are in water shallower than the habitat of their parents, so they face the challenge of either drifting or migrating to deeper water to begin their demersal life. Whether they do so is not known, hence the spring coastal water may be either a benefit for survival or a death trap. *Keywords: Fish, Life history studies, Hydrodynamics.*

WAPLES, J.T.¹, ORLANDINI, K.A.², and KLUMP, J.V.¹, ¹Great Lakes WATER Institute, University of Wisconsin-Milwaukee, Milwaukee; ²Argonne National Laboratory, Argonne.
Measuring Particle Dynamics and Dreissenid Mussel Clearance Rates with Short-lived Radionuclide Tracers: ⁹⁰Y/⁹⁰Sr & ²³⁴Th/²³⁸U.

Evidence for the interception, retention and re-packaging of suspended material by dreissenid mussels and attempts to quantify this flux have primarily relied on (i) observations of changing inventories over time (e.g., increased water clarity, decreases in chlorophyll); (ii) extrapolation of small-scale laboratory and field experiments and (iii) modeling studies. We propose that particle (nutrient and energy) clearance rates in the water column can be measured directly using naturally occurring short-lived particle reactive radionuclides. Th-234/U-238 ratios have been utilized for decades in marine and freshwater systems as a tracer for particle flux – where a low activity of Th-234 (half-life: 24.1 days) relative to its conservative parent U-238 indicates particle removal on a time scale of days to weeks. A new tracer we have developed utilizes Y-90/Sr-90 disequilibria – where a low activity of Y-90 (half-life: 64 hours) relative to its conservative parent Sr-90 indicates particle removal on a time scale of hours to days. When both tracers (Y-90/Sr-90 & Th-234/U-238) are used in tandem, net particle removal rates on both time scales are measured revealing both the fraction of resuspended material in the water column and the residence time of material on the lakebed. *Keywords: Biogeochemistry, Coastal ecosystems, Dreissena.*

WARNER, D.M.¹, SCHAEFFER, J.S.¹, and CLARAMUNT, R.M.², ¹USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105; ²Michigan Department of Natural Resources Charlevoix Fisheries Research Station, 96 Grant Street, Charlevoix, MI, 49720. **Abundance and Distribution of Native and Non-Native Species in the Changing Pelagia of Lakes Huron and Michigan.**

The decline of *Diporeia* and pelagic preyfish in lakes Michigan and Huron led to several key questions regarding *Mysis relicta*. Has the recent expansion of dreissenids led to a decline of *Mysis relicta* similar to that observed for *Diporeia*? Has there been a change in mysid distribution? Will pelagic fish feed more heavily on *Mysis relicta* in the absence of *Diporeia*? How do distributions of mysids and fish compare within and between lakes? Are the mysid populations currently heavily influenced by predation by pelagic fish? Are mysids food-limited? Can the mysid populations in these lakes support reintroduction of native fish? Data collected during lakewide acoustic surveys in 2005-2007 as well as other studies were used to answer these questions. *Keywords: Mysis, Pelagic fish, Acoustics.*

WARREN, G.J.¹ and DOVE, A.², ¹U.S. Environmental Protection Agency, 77 W. Jackson Blvd., Chicago, IL, 60604; ²Water Quality Monitoring and Surveillance, Environment Canada, Burlington, ON. **Long and Short-Term Nutrient Trends in Lake Huron.**

USEPA Great Lakes Monitoring Program and Environment Canada's Surveillance Program provide some of the most comprehensive, systematic and detailed information that is available worldwide for such a large lake. Long-term trends for nutrients, in general, indicate gradual changes for total phosphorus (decrease) and nitrate (increase). The total phosphorus decrease has accelerated during the past five years, with the decrease being associated with the particulate phosphorus phase. In contrast, nitrogen as dissolved nitrate plus nitrite, continues to increase, while the particulate nitrogen phase has decreased dramatically. During this same time period, dissolved silica continues to increase. Quagga mussel colonization of the deeper waters of Lake Huron is implicated in the decrease in particulate nutrients through removal by filtration. Based on mussel bioenergetics modeling, we show that the deep-living quagga mussels have the potential to decrease particulate nutrients at the rate observed in recent years. *Keywords: Lake Huron, Nutrients, Mussels.*

WARZINIACK, T.¹, FINNOFF, D.², SHOGREN, J.F.², ROTHLISBERGER, J.D.³, and LODGE, D.³, ¹Alfred Weber Institute, University of Heidelberg, Bergheimer Strasse 20, Heidelberg, Germany; ²Department of Economics and Finance, University of Wyoming, Laramie, WY, 82009; ³Department of Biological Sciences, University of Notre Dame, Notre Dame, IN, 46556. **Distributions of the Impacts of Ship-borne Invasions on the Great Lakes Regional Economy.**

This paper presents distributions of the economic impact of ship-borne invasive species based on a computable general equilibrium model of the Great Lakes regional economy and results of a structured expert judgment. The model is extended to evaluate alternative policies for prevention and mitigation and uncertain benefits that may stem from the introduction of certain non-native species. Special attention is paid to the influence trade volume has on the probability of introductions, the effect prevention policies may have on trade, and the effects an invasion would have on Great Lakes recreational fishing and wildlife viewing. *Keywords: Invasive species, Economic impact.*

WATKINS, J.M., MILLS, E.L., and RUDSTAM, L.G., Cornell Biological Field Station, 900 Shackleton Pt Rd, Bridgeport, NY, 13030. **Evaluating the Effect of Quagga Mussel (*Dreissena bugensis*) Exposure on the Native Benthic Amphipod *Diporeia* spp.**

The native amphipod *Diporeia* spp. steadily disappeared from benthic habitats of the lower Great Lakes after zebra and quagga mussels (*Dreissena* spp.) were introduced in the early 1990s. The amphipod is extirpated from Lake Erie and now lives only in the deepest habitats of Lakes Ontario, Huron, and Michigan that have yet to be colonized by quagga mussels. In the Great Lakes, *Diporeia* is rarely present at sites where quagga mussel levels are more than 100 ind per sq m. In contrast, *Diporeia* has coexisted with quagga mussels at levels higher than 1000 ind per sq m in Cayuga Lake (a NY Finger Lake) as early as 2001 (Dermott et al. 2005). One hypothesis, that dreissenids carry a pathogen or are otherwise toxic to *Diporeia*, was tested using a series of exposure experiments. We collected live *Diporeia* from Lake Superior (unaffected), Lake Michigan (population in decline), and Cayuga Lake (unaffected) and exposed them to quagga mussels from Lake Michigan, Lake Ontario, and Cayuga Lake to evaluate the effect of different sources. We saw no significant difference in survival between quagga mussel exposure treatments and no-mussel controls during short-term exposures (28 days), but some indication of a quagga mussel effect on *Diporeia* survival for longer exposures (> 60 days).

Keywords: Benthos, *Dreissena*, *Diporeia*.

WATSON, S.B.¹ and BOYER, G.L.², ¹CCIW Environment Canada, 867 Lakeshore Rd, Burlington, ON, L7R 4A6; ²State University of New York College of Environmental Science and Forestry, Syracuse, NY, 13210. **Cyanobacterial Blooms in Lake Ontario Coastal Areas: Toxins, Taxa and Taste-Odour.**

Low nutrient levels in offshore Lake Ontario waters translate to oligotrophic conditions with low phytoplankton biomass, typically dominated by flagellates, diatoms and other taxa which represent high quality food for grazers. However, coastal areas have seen major changes recently, notably increased shoreline and watershed development, non-point loading, coastal erosion, invasive species and climate change. This has produced major shifts in inshore nutrient cycling, transparency and biota, and in many areas, a re-emergence of benthic and planktonic nuisance algae. Toxic, odourous and beach/intake fouling Harmful Algal Blooms (HABs) have significant economic and ecological impacts. Toxic cyanobacteria are a growing concern in Areas of Concern (Hamilton Harbour, Bay of Quinte, Oswego), while a much broader stretch of shoreline is impacted by dense proliferations of non-toxic benthic algae which . We present current status, risks and toxin levels of these inshore HABs *Keywords:* *Cyanophyta*, *Lake Ontario*, *Harmful algal blooms*.

WATSON, S.B.¹, HUDON, C.², CATTANEO, A.³, and QUILLIAM, M.⁴, ¹Environment Canada, CCIW, 867 Lakeshore Rd, Burlington, ON, L7R 4A6; ²Environnement Canada, Centre St. Laurent, 105, rue McGill, Montréal, PQ, H2Y 2E7; ³Département de sciences biologiques, Université de Montréal, C. P. 6128, succ. Centre Ville, Montréal, PQ, H3C 3J7; ⁴National Research Council Canada, Institute for Marine Biosciences, 1411 Oxford St, Halifax, NS, B3H

3Z1. Benthic Cyanobacterial Mats in the Great Lakes and the St Lawrence: Ecological and Socioeconomic Impacts.

Dense benthic algal proliferation is an increasing problem in littoral areas of the Lower Laurentian Great Lakes and St. Lawrence River (LGL-SLR). The re-emergence of *Cladophora* in these lakes has promoted considerable research into causes and controls, but a second, perhaps more insidious threat has recently emerged. Dense, spatially segregated mats of benthic cyanobacteria (dominated by *Lyngbya cf. wollei*) have been reported from some of the major rivers. These mats have the potential to produce toxins, and/or organic volatile compounds (geosmin and MIB) which impart airborne or drinking water taste and odour. We assessed the distribution and environmental characteristics of these mats in major rivers and connecting channels across the LGL-SLR, and characterized them for taxonomic identity, toxins and VOCs, during a 950-km survey of over 40 tributaries of lakes Erie, Ontario and of the St. Lawrence River (between Windsor and Trois-Rivières) in late summer 2008. Major results indicate i) relationships between these mats and key environmental parameters, including light and nutrient levels, ii) differences in VOCs and toxins among mats from different sites; analyses by LC-MS identified several saxitoxin analogues, some with new structures; iii) major impairment at some sites reflecting degraded water quality. *Keywords: Cyanophyta, Benthic flora, Biological invasions.*

WATTON, J.P. and GRABAS, G.P., 4905 Dufferin Street, Toronto, ON, M3H 5T4. Developing a Method to Monitor Vegetation Community Dynamics in Great Lakes Coastal Wetlands.

Wetland vegetation is a cornerstone for fish and wildlife habitat in Great Lakes coastal wetlands. The extent, composition and interspersions of vegetation communities greatly influence habitat availability and quality for wildlife. Vegetation community zonation in temperate wetlands is primarily driven by topography and hydrology. Great Lakes water level fluctuations have had notable effects on coastal wetland vegetation community structure and subsequent functioning, particularly in the Lake Ontario basin where levels are regulated. The purpose of this study is to develop a methodology to monitor the extent and composition of vegetation communities along the elevation gradient in selected Great Lakes coastal wetlands and detect their advance or retreat over time. A Real-time Kinematic Global Positioning System, was used to capture centimetre-level, elevation intervals in combination with vegetation quadrat sampling. Furthermore, results from a new survey methodology for establishing fixed benchmarks at select Great Lakes coastal wetlands indicate the RTK-GPS equipment is capable of collecting data with high accuracy. This finding will facilitate the creation of long term monitoring sites to document water level management effects on fish and wildlife habitat. *Keywords: Vegetation, GPS, Water level.*

WENDT, D.P., 3023 Ferndale Street, Kensington, MD, 20895. A Trade Lawyer's Comment on the Great Lakes Compact, the Bottled Water Loophole, and Trade Agreements.

The Great Lakes Compact prohibits diversions of water from the Great Lakes basin, with some notable exceptions. One exception is for shipments of bottled water (i.e., water in

containers of 5.7 gallons or less) to regions outside the basin. Advocates for and against the bottled water loophole have both pointed to trade agreements (in particular, NAFTA and the WTO Agreements) either to defend or attack the loophole. In these discussions, there have been numerous statements about the trade agreements or their enforcement that have been at least misleading, and sometimes untrue. These misstatements have a significant effect on the debate surrounding whether and how bottled water should be regulated in the Great Lakes region. Most significantly, these misstatements have precluded a pragmatic, nuanced, and realistic debate about whether the Great Lakes can regulate bottled water, and what - if any -- would be the costs to do so, given the United States' commitments under the NAFTA and the WTO Agreements. The debate surrounding bottled water should focus on several questions beyond the preliminary question of whether bottled water exports are subject to trade agreement commitments.

Keywords: Diversion, Bottled water, International trade.

WHITE, B.A.¹, MATSUMOTO, K.¹, and AUSTIN, J.A.², ¹University of Minnesota, Minneapolis, MN; ²University of Minnesota - Duluth, Duluth, MN. **Implications of Ice Cover Decrease for Lake Superior Biogeochemistry: A Numerical Modeling Study.**

Annual physical and biogeochemical dynamics in the North American Great Lakes are tightly coupled due to strong seasonal forcing. Regional climate change has influenced and will continue to influence the physical dynamics in these temperate lakes. There is a negative trend in average areal ice coverage on Lake Superior due to regional climate change (Austin and Colman, 2007). An unexpectedly strong positive trend in summer surface water temperatures (twice the rate of regional atmospheric temperature increase) also exists. We use numerical modeling to study the impacts of regional climate change driven physical dynamics on biogeochemical dynamics within Lake Superior. The Regional Ocean Modeling System (ROMS), a three-dimensional high resolution hydrodynamic model, is used. A dynamic-thermodynamic sea ice model is coupled to the physical model. An ecological-biogeochemical model based on the Fasham et al. (1990) NPZD model but with multiple plankton size classes and biological limitation by phosphorus, is used. We report the results of our sensitivity experiments examining the effects of variability in winter ice coverage and increasing surface water temperatures on seasonal biogeochemical dynamics in Lake Superior. *Keywords: Biogeochemistry, Climate change, Ice.*

WHITELAW, G.S.¹ and EAGLES, P.F.², ¹Queen's University, School of Environmental Studies, Kingston, On, K7L 3N6, Canada; ²University of Waterloo, Department of Recreation, Waterloo, On, N2L 3G5, Canada. **Regional Environmental Land Use Planning Activities Benefitting Great Lakes Protection: Case Studies of the Niagara Escarpment and Oak Ridges Moraine, Ontario Canada.**

The relationship between protection of Great Lakes water quality and strong environmental land use planning is well recognized. Results from research on environmental land use planning in the Lake Ontario basin in the areas covered by the Niagara Escarpment and Oak Ridges Moraine, Ontario, Canada will be presented. These two cases together reveal an evolution of environmental land use planning towards collaborative processes over the period

from 1960 through 2002. The results suggest that civil society organizations created new planning domains by establishing new or modified landscape planning boundaries through agenda setting activities. Furthermore, these organizations contributed to changes in planning regimes through agenda setting and collaborative efforts with other stakeholders leading the Ontario government to adopt new legal and planning rules. These new rules resulted in improved natural heritage system delineation and protection, and implementation of leading edge water policies. Extensive core and corridor areas including headwaters along with major portions of rivers and streams flowing into Lake Ontario were protected enhancing Lake Ontario management efforts. *Keywords: Conservation, Environmental policy, Lake Ontario.*

WILEY, M.J.¹, PIJANOWSKI, B.C.², KOCHES, J.³, RISENG, C.M.¹, STEVENSON, R.J.⁴, SEELBACH, P.W.¹, CHENG, S.T.¹, KENDALL, A.D.⁴, HYNDMAN, D.⁴, RICHARDS, P.⁵, RUTHERFORD, E.S.⁶, TYLER, J.A.⁷, CARLSON, M.⁹, and STEEN, P.J.⁸, ¹University of Michigan, Ann Arbor, MI; ²Purdue University, Lafayette, IN; ³Grand Valley State University, Muskegon, MI; ⁴Michigan State University, East Lansing, MI; ⁵SUNY Brockport, Brockport, NY; ⁶National Oceanic Atmospheric Administration, Ann Arbor, MI; ⁷Fisheries Projections, Ltd, Farmington, CN; ⁸Huron River Watershed Council, Ann Arbor, MI; ⁹U.S. Geological Services, Ann Arbor, MI. **A Multi-Modeling Approach to Great Lakes Watershed Planning: the Muskegon Mega-Model.**

The pace of both climate and landscape modification has made planning for watershed vulnerability to change a key challenge for the twenty-first century. River ecosystems are directly dependent on climate patterns and landscape composition for their characteristic water and material budgets. The Muskegon River Ecological Modeling System (MREMS) uses a multi-modeling approach to couple an array of models operating a different characteristic scales in time and space as a way of evaluating strategies for adaptation to future change. Beginning with climate and land use change models, the system tracks water budgets, material budgets, and biological community and population responses through scenario simulations. The result is an open modeling system capable of predicting future (and past) states of the landscape using alternate climate scenarios, and then evaluating likely changes in river hydrology, chemistry, and biological integrity/productivity in a spatially explicit framework. In this presentation we provide a quick overview of the development, direction by regional stakeholders, and public availability of the MREMS system and its output. *Keywords: Model studies, Watersheds, Ecosystem modeling.*

WILEY, M.J.¹, PIJANOWSKI, B.C.², KENDALL, A.D.³, HYNDMAN, D.³, CARLSON, M.¹, LADEWIG, M.¹, RISENG, C.M.¹, KOCHES, J.⁴, STEVENSON, R.J.³, SEELBACH, P.W.¹, and RICHARDS, P.⁵, ¹University of Michigan, Ann Arbor, MI; ²Purdue University, Lafayette, IN; ³Michigan State University, East Lansing, MI; ⁴Annis Water Resources Center, Grand Valley State University, Muskegon, MI; ⁵SUNY Brockport, Brockport, NY. **Nutrient and Sediment Load Responses to Land Management and Climate Change in the Muskegon River Watershed: a Modeling Assessment.**

Using a series of linked land cover, climate, hydrologic, nutrient loading, and geomorphic models we examined how future land cover configuration and climate change might interact to shape nutrient (N and P), suspended sediment, and bed load transport across the Muskegon River watershed. A down-scaled climate model based on the A1B scenario (4th IPCC) resulted in increases in both baseflow and runoff relative to historical flows for much of the basin. Increasing water loads in turn drove increased nutrient delivery to in-line reservoirs and lakes, and widespread channel de-stabilization. The land use scenario which maximized retention of forest cover showed the smallest increases in erosion and loading under changed climate but still had substantial increases in both nutrient and sediment flux. The land use scenario maximizing agricultural land cover showed the largest increases. We discuss the implications of these results to regional preparations for climate change adaptation, and the extent to which the result is constrained by our modeling methodology. *Keywords: Ecosystem modeling, Nutrients, Climate change.*

WILEY, M.J.¹, PIJANOWSKI, B.C.², KENDALL, A.D.³, RISENG, C.M.¹, CHENG, S.T.¹, STEEN, P.J.⁴, HYNDMAN, D.³, RICHARDS, P.⁵, RUTHERFORD, E.S.⁶, TYLER, J.A.⁷, CARLSON, M.¹, STEVENSON, R.J.³, SEELBACH, P.W.¹, and KOCHES, J.⁸, ¹University of Michigan, Ann Arbor, MI; ²Purdue University, Lafayette, IN; ³Michigan State University, East Lansing, MI; ⁴Huron River Watershed Council, Ann Arbor, MI; ⁵SUNY Brockport, Brockport, NY; ⁶National Oceanic Atmospheric Administration, Ann Arbor, MI; ⁷Fisheries Projections, Ltd, Farmington, CN; ⁸Annis Water Resources Center, Grand Valley State University, Muskegon, MI. **A Multi-Modeling Approach to Evaluating Impacts of Climate Change on River Ecosystems.**

Rivers ecosystems consist of complex linkages between very dynamic physical, chemical and biological subsystems; each operating at different characteristic scales and frequencies. This complexity makes ecological forecasting difficult, and is one of the obstacles slowing regional preparation for ecological adaptation to anticipated climate change. We describe a recently developed “multi-modeling” system for ecological forecasting in a moderately large (5500 km²) watershed in the N.A. Great Lakes basin. Using a series of linked land cover, climate, hydrologic, hydraulic, loading, and biological response models we examined how land cover and climate change may interact to shape the habitat suitability of river segments for common sport fishes and general biological integrity metrics. Because water temperature has a controlling influence on individual species distributions, individual sport fishes were more sensitive to climate change than to land cover change. However, community-based biological integrity metrics were more sensitive to land use change than climate change despite similarities in modeling approach. We discuss the implications of this result to regional preparations for climate change adaptation, and the extent to which the result may be constrained by our modeling methodology. *Keywords: Climate change, Ecosystem modeling, Watersheds.*

WILLEY, J.C. and CRAWFORD, E.L., Room 219 HEB University of Toledo HSC, 3000 Arlington Avenue, Toledo, OH, 43614. **Quality-Controlled RT-PCR Data That Support Development of New Diagnostics.**

Standardized reverse transcriptase polymerase chain reaction (StaRT-PCR) is a modification of the competitive template (CT) RT method. StaRT-PCR allows rapid, reproducible, standardized, quantitative measurement of data for many genes simultaneously. An internal standard CT is prepared for each gene, cloned to generate enough for >109 assays and CTs for up to 1000 genes are mixed together. Each target gene is normalized to a reference gene to control for cDNA loaded into the reaction. Each target gene and reference gene is measured relative to its respective internal standard within the SMIS. This method provides intrinsic quality control for interfering substances such as PCR inhibitors, and prevents false negative or false positive results. In contrast methods that use external standard curves for quantification do not control for substances that interfere with the PCR reaction. Because each target gene and reference gene is simultaneously measured relative to a known number of internal standard molecules in the SMIS, it is possible to report each gene expression measurement as a numerical value in units of target gene cDNA molecules/ 106 reference gene cDNA molecules.

Keywords: Fish diseases, Lake Erie, Bioindicators.

WILSON, W.¹ and SEPULVEDA VILLET, O.J.², ¹Roy C. Start High School, 2010 Tremainsville Road, Toledo, OH, 43613; ²Lake Erie Center, University of Toledo, 6200 Bayshore Rd., Toledo, OH, 43618. **Sixteen Years of Water Quality Monitoring: Shantee Creek at Roy C. Start High School.**

Shantee Creek runs through west Toledo and joins Silver Creek, then flows into Halfway Creek and drains to Lake Erie. Start HS has collected Student Watershed Watch (SWW) data since 1992. We sampled Shantee Creek as it passes through Start HS, at morning and in the afternoon. Our goal is to compare our results to those of previous years. Morning and afternoon temperatures changed as Shantee Creek is very shallow at the sampling site, and there was full sun exposure. Nutrients (nitrate, phosphorus), turbidity (320mm) and coliform (1320 CF/100ml) counts were high, most likely due to runoff from backyards or other sources into the Creek. Large rain events on the eve of the sampling event may contribute to rapid changes from yearly average measurements. Dissolved oxygen was low (6.0 mg/l) and high biochemical oxygen (5.2 mg/l) demand values indicate a large amount of organic matter washed into the creek during the rain. Historical measurements show high variation, which may be due to rain or other weather events, indicating stream conditions might change dramatically from year to year, even if streams are sampled at similar times of the year. The Student Watershed Watch is a successful field program to introduce water quality monitoring to high school students.

Keywords: Watersheds, Monitoring, Education.

WINSTON, G.W.¹, LAUBENDER, B.G.¹, YI, S.X.², KRIEGER, K.A.¹, SCHLOESSER, D.W.³, and LEE, R.E.², ¹National Center for Water Quality Research, Heidelberg University, Tiffin, OH, 44883; ²Department of Zoology, Miami University, Oxford, OH, 45056; ³United States Geological Survey, Great Lakes Science Center, Ann Arbor, MI, 48105. **Oxidative Stress Indicators in the Mayfly *Hexagenia limbata*: Responses to Cold Shock, Heat Shock, Desiccation and Parasitic infection.**

Mayfly (*Hexagenia*) abundance is a key indicator of Lake Erie environmental quality. Mayfly larvae are very vulnerable to environmental stress. Oxidative stress is a general response to environmental stressors. There is a lack of research on biochemical responses to oxidative stress in *Hexagenia*. Oxidative stress occurs when reactive oxygen species overwhelm antioxidant defenses. Enzymatic activities (mean \pm SD) in post 9000 x g extract were for catalase (CAT, 14.8 ± 1.3), glutathione peroxidase (GPx, 1.4 ± 0.7), glutathione reductase (GR, 4.9 ± 0.5), glutathione S-transferase (GST, 35.5 ± 4.4) nmol/min/mg and superoxide dismutase (SOD, 7.5 units/mg). Activities of GST, CAT, and SOD were studied in parasite-infected and non-infected larvae. GST activity of non-infected larvae was elevated by heat-shock in all cases. Desiccation and heat-shock lowered and cold-shock elevated GST activity relative to controls in parasite-infected larvae. CAT activity was not altered in non-infected larvae by desiccation, cold- or heat-shock. In parasite-infected larvae heat-shock resulted in higher CAT activity. Heat-shock elevated SOD activity over all cold-shocked, desiccated and control larvae. These results indicate presence of antioxidant enzymes in *Hexagenia* larval extracts and up- or down-regulation of antioxidant defenses by the stressors. *Keywords: Oxidative stress, Oxygen, Hexagenia spp., Lake Erie, Biomarker, Biomonitoring.*

WITTER, D.L.¹, ORTIZ, J.D.¹, PALM, S.², HEATH, R.T.³, and BUDD, J.W.⁴, ¹Department of Geology, Kent State University, Kent, OH, 44242; ²Bayfront Medical Center, 701 6th Street, St. Petersburg, FL, 33701; ³Department of Biological Sciences, Kent State University, Kent, OH, 44242; ⁴Science Department, Finlandia University, Hancock, MI, 49931. **Evaluating Strategies for Retrieving Lake Erie Chlorophyll *a* Concentrations from SeaWiFS Observations.**

The feasibility of monitoring chlorophyll *a* concentrations in the optically complex waters of Lake Erie is assessed by comparing SeaWiFS chlorophyll *a* retrievals from 12 marine algorithms and an ensemble of regionally derived algorithms with fluorescence-based measurements from 68 field samples collected across the lake between 1998 and 2002. In all basins of the lake, the marine algorithms performed poorly, with most consistently overestimating low chlorophyll *a* concentrations and many underestimating higher chlorophyll *a* concentrations. The possibility for improving chlorophyll *a* retrievals through the use of regionally tuned algorithm coefficients was assessed. Regional algorithms performed significantly better than marine algorithms in the eastern and central basins, thus the outlook for regionally tuning algorithm coefficients is promising in these areas. In the western basin, regional algorithms produced retrievals with unacceptably large error, suggesting that other approaches are necessary in this region of the lake. *Keywords: Phytoplankton, Remote sensing, Lake Erie.*

WU, C., WITTER, J.D., and SPONGBERG, A.L., Department of Environmental Sciences, University of Toledo, 2801 West Bancroft St., Toledo, OH, 43607. **Pharmaceutical and Personal Care Products in an Agricultural Landscape, Western Lake Erie Basin.**

Pharmaceutical and Personal Care Products (PPCPs) as a group of emerging contaminants are receiving growing concern. In this work, the occurrence of eighteen PPCPs was monitored in an agricultural setting in the western basin of Lake Erie from April to November in

2008. Agricultural fields applied with biosolids, and receiving waters and sediments were collected for the analysis of PPCPs. Results indicate the occurrence of many target compounds in both water and biosolids at concentration levels comparable to those reported in the literature. Background and post application concentrations in soil from biosolids amended fields were below method detection limits and no analytes were detected in the sediments, suggesting that the selected PPCPs were unlikely to accumulate. Several compounds were detected in drainage from an amended field following biosolids application. However, the concentrations dropped below detection within a few weeks. Our results suggest that biosolids can introduce certain PPCPs into the receiving waters temporarily while the recurring source may be related to runoff from other point sources. *Keywords: Biosolids, Western Lake Erie Basin, PPCPs.*

WU, C.H. and ANDERSON, J.D., Civil and Environmental Engineering Dept., University of Wisconsin-Madison, Madison, WI, 53706. **Role of High Frequency Water Level Fluctuations on Bed Shear Stress in the Sheboygan River.**

Water level fluctuations up to 40 cm with periods of 15 ~ 30 minutes after storm events were observed in the Sheboygan River Estuary, Wisconsin. Fluctuations are amplified inside the harbor and bottom oscillatory velocities near the bed are therefore increased. Temperature stratification caused by intrusion of cold water in Lake Michigan is found to affect near bed velocities created by the high frequency water level fluctuations. We calculate bottom shear stresses from the velocity records during river base flow and flood conditions. It is found that the magnitude of shear stresses induced by high frequency fluctuations is equivalent to those caused by 5-year flood events. Amplitudes of high frequency fluctuations increase for larger flood events, suggesting that bed shear stresses can be further amplified to cause severe erosion of contaminated sediments on the site. Results of this study will serve to aid the assessment of ecosystems related to sediment transport in the estuaries of the Great Lakes. *Keywords: Water level fluctuations, Sediment resuspension, Hydrodynamics.*

WUEST, A. and SCHMID, M., Eawag, Eawag, Kastanienbaum, CH-6047, Switzerland. **Birth, Rapid Development and Sudden Death of a Distinct Double-Diffusive Staircase in Lake Nyos.**

During the dry season 2002, cooling triggered the formation of a double-diffusive regime below the chemocline in Lake Nyos. Thereafter, the extent of the double-diffusive zone continuously increased, following Fickian diffusion. In summer 2004 the zone embraced a 40 m vertical section and the base reached to 92 m depth. The external stirring is very weak and can not disturb the fate of the staircase. The lake represents a perfect natural environment to study the development of a double-diffusive staircase outside laboratory conditions. Rapidly after initiation of the phenomenon, the number of perfectly-mixed layers reached 27. Since then, it remained constant, although new layers were continuously formed at the expanding base of the double-diffusive zone. It implies that the layer-merging rate was identical to the rate of formation, which was ~1 per month. The formation of the double-diffusive staircase leads temporarily to divergence of the vertical heat flux. The layer thickness increased to more than 1.3 m and the vertical extent of the interface increased and weakened the intensity of the double-

diffusion. This weakening reduced salt, gas and heat fluxes through the staircase until the convection collapsed after ~900 days of its existence, and layers and interfaces eroded away.

Keywords: Africa, Dissolved solids, Risk assessment.

WYNNE, T.T.¹, STUMPF, R.P.¹, TOMLINSON, M.C.¹, and DYBLE BRESSIE, J.², ¹1305 East-West Highway, Silver Spring, MD, 20910; ²4840 South State Road, Ann Arbor, MI, 48108.

Using Satellite Imagery to Determine the Role of Wind and other Environmental Conditions on Cyanobacterial Bloom Movement and Dispersal in Western Lake Erie.

A bloom of the potentially toxic cyanobacterium, *Microcystis aeruginosa*, was detected in western Lake Erie from the MERIS sensor on the Envisat satellite during the summer of 2008. The distribution and rough cell concentration of a near-surface bloom (down to 1 m) can be determined based on the MERIS imagery. The surface movement of the bloom was driven by wind stress over the two month period, at which point a drop in water temperature below 15C may have caused the bloom to disappear. The effects of light availability, water temperature and wind stress were investigated for the entire time series. Wind stress provided by the National Data Buoy Center indicates that the bloom was mixed into the water column during high winds (>0.1 Pa) and reappeared at the surface during low winds (<0.1 Pa). The results of this analysis are a first step at developing a rule-based model in an effort to estimate the conditions conducive to bloom formation and dispersal. Further analysis is required to appropriately correlate satellite-observed variations with bloom intensity. *Keywords: Cyanophyta, Microcystis, Remote sensing.*

XIA, M.¹, SCHWAB, D.J.², and ANDERSON, E.J.², ¹Cooperative Institute of Limnology and Ecosystem Research, University of Michigan, Ann Arbor, MI, 48108, US; ²Great Lakes Environmental Research Lab, National Oceanic Atmospheric Administration, Ann Arbor, MI, 48108, US. **The Hydrodynamic Modeling of Grand Haven River using Finite Volume Coastal Ocean Model (FVCOM).**

A three-dimensional coupled wave-current model is applied to simulate wave effects on the structure of currents, water level fluctuations in the Grand Haven River and adjacent beach areas. This presentation will calibrate the model with the help of observational data. In addition, it also shows insight regarding how the wave effect on the structure of the currents. The influence of wave to the near shore circulation will also be discussed by using this high resolution unstructured grid model. *Keywords: Waves, Hydrodynamic model, Coastal processes.*

XIA, X.¹ and MILLER, D.H.², ¹CSC, Large Lakes Research Station, 9311 Groh Road, Grosse Ile, MI, 48138; ²USEPA, ORD, NHEERL, Mid-Continent Ecology Division, 9311 Groh Road, Grosse Ile, MI, 48138. **Spatial Patterns Study for Sediments from Lake Michigan.**

Accurately understanding the distribution of sediment measurements within large water bodies is critical for understanding and modeling of carbon, nitrogen, silica and phosphorus dynamics. As part of the LMMB Study, sampling of sediment in Lake Michigan for nutrients was conducted by USEPA (1994). In our modeling practices, data often need to be populated to

cover a high resolution grid of 5km by 5km of Lake Michigan. Estimations which take into account spatial patterns of data will generate better representative prediction in practice. Spatial statistics were used to investigate and justify the spatial patterns of the data. Our quantified results suggest that there is a strong correlation between the sediment parameters and the water depths. Also, the distribution of sediment nutrient and carbon measurements within Lake Michigan is observed to vary considerably. We have explored a variety of approaches, including data stratification and 3D interpolations, where samples depths can be used to estimate variogram and covariance functions, to incorporate the spatial patterns into data applications to get better statistical inferences. Test results have shown improvements over the estimations without using spatial patterns. Results of this study can be used for sediment and modeling applications beyond Lake Michigan. *Keywords: Sediments, Lake Michigan, Spatial analysis.*

YERUBANDI, R., HUANG, A., ZHAO, J., and LU, Y., Environment Canada, Canada Centre for Inland Waters, Burlington, ON. **Hydrodynamic Modelling of Lake Ontario: An Intercomparison of three hydrodynamic models.**

The Laurentian Great Lakes have horizontal scales of hundreds of kilometers and depth scales of hundreds of meters. The lakes have a profound influence on the local weather. Currently, the lake-ice component of the operational atmospheric system in the Canadian Meteorological Centre is treated as static, with the water surface temperature values being specified based on observations for determining heat fluxes into the atmosphere at the surface of the lake. However the air-lake interface is dynamic with momentum exchange, heat exchange and moisture/water exchange. Recognizing these needs Environment Canada in collaboration with other agencies started developing a framework for coupling of weather prediction models with hydrological and lake models. As part of the project three existing lake models namely, Princeton Ocean Model (POM) and Estuary Lake Coastal Ocean Model (ELCOM) and Canadian Version of DieCAST (CANDIE) will be applied to the lower Great Lakes. An intercomparison of these models with the time series observations of circulation and temperature from April to October, 2006 has been carried out in Lake Ontario. In this paper, we describe preliminary results of temperature, water levels and circulation obtained from these three hydrodynamic models in Lake Ontario *Keywords: Hydrodynamic model, Lake Ontario, Atmosphere-lake interaction.*

YI, S.X.¹, WINSTON, G.W.², LAUBENDER, B.G.², SCHLOESSER, D.W.³, and LEE, R.E.¹, ¹Department Of Zoology, Miami University, Oxford, OH, 45056; ²National Center for Water Quality Research, Heidelberg College, Tiffin, OH, 44883; ³U.S. Geological Survey, Great Lakes Science Center, Ann Arbor, MI, 48105. **Bio-Indicators of Cellular Stress in the Mayfly *Hexagenia limbata*: Potential Roles for Heat Shock Proteins.**

Although mayflies are key indicators of environmental recovery, little research has examined cellular and molecular responses to environmental stress. Heat shock proteins (Hsps) are ubiquitous molecules induced in all living cells in response to various stresses. Using SDS-PAGE and immuno-blotting techniques, we conducted a preliminary study of the effects of several potential environmental stresses including desiccation, cold shock, and heat shock on the

expression levels of two important families of Hsps, Hsp70 and small Hsps, in nematode-infected and non-infected mayfly nymphs of *H. limbata* collected from Lake Erie in June, 2008. Our data show: (1) protein expression of Hsp70 was induced by desiccation in parasitized nymphs, and by cold shock in unparasitized nymphs, and (2) expression levels of small Hsps were also affected by these environmental stresses. In parasitized nymphs, heat shock induced Hsp26 monomers, and desiccation induced dimers and oligomers. In the unparasitized group, both desiccation and heat shock increased the levels of the Hsp22 monomer, whereas the levels of a hexamer increased in all treatments compared with controls. Our tentative results suggest that Hsps serve as stress indicators in mayfly nymphs and that Hsp expression is influenced by parasitization of the host.

YOUNG, B.T. and PENNUTO, C.M., 1300 Elmwood Avenue, Buffalo, NY, 14222. **The Role of Environmental Context and Mutual Predation in Amphipod Invasion Success in the Great Lakes.**

The benthic amphipod, *Echinogammarus ischnus*, was first introduced into North American waters in 1995, and has become the most abundant amphipod species in many littoral zone locations, surpassing the native, *Gammarus fasciatus*. Stable isotope work indicates these species reside at different trophic positions, suggesting one is more predatory than the other. Since intraguild predation (IGP) has been shown to be an important factor in amphipod invasion success in European systems, we investigated the strength of cannibalism within and IGP between these species under varying conditions of substrate complexity, body size, and temperature. Statistical analyses will be performed using ANOVA procedures to determine whether environmental context shapes cannibalism and/or IGP outcomes. Early analysis suggests that substrate complexity and water temperature played important roles in determining the outcome of IGP and cannibalism interactions between and within these species. Preliminary results also indicated that the native amphipod, *G. fasciatus* was more predatory than the invasive species, *E. ischnus*, contrary to stable isotope results. Further analyses will provide a better understanding of the role of IGP in the invasion success of non-indigenous amphipod species in the Great Lakes. *Keywords: Invasive species, Amphipoda, Ponto-Caspian basin, Great Lakes basin.*

YUILLE, M.J.¹, JOHNSON, T.B.¹, SCHANER, T.¹, and BOWEN, K.L.², ¹Glenora Fisheries Station, Picton, ON, K0K 2T0; ²Fisheries and Oceans Canada, Burlington, ON, L7R 4A6. ***Hemimysis anomala* in Lake Ontario – Distribution and Food Web Effects.**

In 2006 the Ponto-Caspian invader *Hemimysis anomala* was observed at two locations in the Great Lakes basin. In 2007 and 2008, a collaborative effort between the Ontario Ministry of Natural Resources and the Department of Fisheries and Oceans Canada determined an increasing density of *H. anomala* from east to west on the northern shore of Lake Ontario. A variety of fish species were sampled along this invasion front and four species (rock bass, round goby, yellow perch and alewife), each representing different trophic guilds, were selected to assess the impact of *H. anomala* on fish condition and health as well as its impact on the Lake Ontario food web. Examination of fish stomach contents confirmed that *H. anomala* have been incorporated into

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

the Lake Ontario food web and stable isotope and tissue analyses provided further support of dietary and energy flow shifts within the food web. On-going analyses will add fatty acid and chemical tracers to further examine bioenergetic and toxicokinetic consequences following the insertion of *H. anomala* into the Lake Ontario food web. *Keywords: Invasive species, Hemimysis anomala, Lake Ontario, Fish diets.*

YURISTA, P.M., KELLY, J.R., MILLER, S.E., and VAN ALSTINE, J., US EPA Midcontinent Ecology Division, 6201 Congdon Blvd, Duluth, MN, 55804, USA. **Spatial Patterns in Water Quality and Plankton for the US Waters of Nearshore Lake Huron, 2007.**

We conducted an intensive survey for the US nearshore of Lake Huron along a continuous segment (523 km) from Detour Passage to Port Huron Michigan. A depth contour of 20 m was towed with a CTD, fluorometer, transmissometer, and laser optical plankton counter (LOPC). The continuous electronic data stream provided a high resolution image of spatial variability both vertically and horizontally for each parameter. Measured parameters within the lake were related to summarized watershed landuse indices using stepwise linear regressions. A repeat tow showed a temporal robustness in spatial patterns. Lake Huron nearshore is briefly compared to similar nearshore measurements in Lake Superior. This abstract does not necessarily reflect EPA policy. *Keywords: Assessments, Lake Huron, Ecosystems.*

ZAIKO, A., OLENIN, S., DAUNYS, D., and PASKAUSKAS, R., H. Manto 84, Klaipeda, LT92294, Lithuania. **200 Years with Zebra Mussel: Lessons Learned in the SE Baltic Sea.**

The Curonian lagoon (SE Baltic), being the largest lagoon in Europe, also has been (and is now) a subject for the numerous alien species invasions. Among others, zebra mussel (*Dreissena polymorpha*) invasion must be emphasized due to its long presence in the Curonian lagoon (the first introduction was reported in 1800s (Olenin et al. 1999b) and its substantial impact on the virtually every part of the ecosystem. Zebra mussel is known as an extremely aggressive invader in the most aquatic ecosystems where it has been introduced. It alters habitats, causes considerable shift in benthos and plankton community properties, induces biogeochemical changes in the benthic and pelagic environments. This study provides the realistic evaluation of the significance of different zebra mussel impacts in context of the Curonian lagoon ecosystem. The importance and effect of different zebra mussel functions were evaluated for separate lagoon's communities and for the whole ecosystem. The impacts of such poorly studied phenomenon as zebra mussel shell deposits have been described and quantified. The biogeochemical alterations of benthic habitats induced by zebra mussel presence and functioning were investigated in situ and linked to the structure of the macrozoobenthos community. *Keywords: Zoobenthos, Ecosystem engineer, Habitats, Soft bottom, Zebra mussels, Benthic community.*

ZHANG, L.² and WEISENER, C.¹, ¹GLIER, University of Windsor, Windsor, ON, N9P 3P4; ²GLIER, University of Windsor, Windsor, ON, N9P 3P4. **The Past, Current and Future of Water Quality in Yangtze River.**

Being the largest river in Euro-Asian continent, the Yangtze River is a critical water resource for China. The Three Gorges Dam (TGD) Project, ever built and results in the deepest artificial lake in the world (2335 m long and 185 m depth), is located in the up reaches of the Yangtze River in south-central China. Hydrologic conditions of the Yangtze River have changed markedly since the initial impoundment in July 2003, setting an example of how water quality has changed along with the big dam construction. The water depth in TGD region has increased to 65 m. Sands concentration in the dam has dropped from $0.578 \text{ kg}\cdot\text{m}^{-3}$ to $0.155 \text{ kg}\cdot\text{m}^{-3}$; average flow velocity in the main channel has dropped from $0.85 \text{ m}\cdot\text{s}^{-1}$ to $0.20 \text{ m}\cdot\text{s}^{-1}$; in some of the tributaries, the water level has increased 40m and the water flow velocity has dropped from the original $0.43\text{--}0.92 \text{ m}\cdot\text{s}^{-1}$ to $0.0020\text{--}0.0041 \text{ m}\cdot\text{s}^{-1}$. The retention time of the water in the reservoir is estimated to be 77 days. Concentrations TN and TP as well as the biomass and composition of phytoplankton and zooplankton have significantly changed. Urban and rural areas discharge to the river and tributaries from 2003 to Nov, 2008, revealed rapid eutrophication in this aquatic system. *Keywords: Reservoirs, Water quality, Eutrophication.*

ZHANG, X.M.¹, RYGWELSKI, K.R.², ROSSMANN, R.², and KREIS, R.G.², ¹Z-Tech Corporation, an ICF International Company, Large Lakes Research Station, 9311 Groh Rd., Grosse Ile, MI, 48138; ²U.S. EPA, ORD, NHEERL, Mid-Continent Ecology Division, Large Lakes Research Station, 9311 Groh Rd., Grosse Ile, MI, 48138. **A Mercury Transport and Fate Model for Mass Budget Assessment of Mercury Cycling in Lake Michigan.**

A mercury mass balance model was developed to describe and evaluate the fate, transport, and biogeochemical transformations of mercury in Lake Michigan. Coupling with total suspendable solids (TSS) and dissolved organic carbon (DOC), the mercury transport and fate model simulates total mercury and three mercury species including elemental mercury, divalent mercury, and methylmercury. The model was designed to have enough sophistication in overall model conceptualization to capture key processes but at the same time maintain simplicity of speciation processes where permitted. Comparing model output with observed data generated during the Lake Michigan Mass Balance project, model calibration was performed for each state variable. Using this calibrated model, mass budget analysis was applied to assess mercury cycling in Lake Michigan. Model-derived mass flow rates within a mass budget assessment helped to quantitatively identify key environmental transport and fate processes controlling the concentrations of mercury species in both the water and sediments of the lake. The relative magnitude of these model-derived mass flow rates were also compared to measured mercury load contributions to the lake. This abstract does not necessarily reflect USEPA policy.

Keywords: Ecosystem modeling, Lake Michigan, Mercury.

ZHOU, H.¹, GREEN, N.D.¹, DROUIN, R.², BRIGGS, T.³, CARGNELLI, L.⁴, and HAFFNER, G.D.⁵, ¹Detroit River Canadian Cleanup, 311-360 Fairview Avenue West, Essex, ON, N8M 1Y6; ²Ontario Ministry of Natural Resources, Lake Erie Management Unit, London, ON, N6E 1L3; ³Ontario Ministry of the Environment, 733 Exeter Road, London, ON, N6E 1L3; ⁴Environment Canada, Restoration Programs Division, Burlington, ON, L7R 4A6; ⁵Great Lakes Institute for

Environmental Research, University of Windsor, Windsor, ON, N9B 3P4. **Detroit River Delisting & Information System: A Management Tool for an Area of Concern.**

In 1985, the Detroit River was officially designated as one of 43 Areas of Concern (AOC) in the Great Lakes Basin. Cleanup of the AOCs requires cooperation from the community, industry, and all levels of government to implement actions from locally-driven remedial action plans (RAPs). The Detroit River Delisting and Information System (DRDIS) is a newly-developed information system and data repository that will be an important resource for managing and delisting the Detroit River AOC. Key features include information storage and management, full site searching, protected access to information, and uploading and downloading of resources within four main modules (Policy Framework, Corporate Memory, Metadata Database, and Resources) in one convenient location. The DRDIS will house all of the supporting documents for the RAP making all aspects of delisting and management function efficiently and transparently. The DRDIS is an excellent example for information management in any multi-jurisdictional management program, including RAPs. *Keywords: Information System, Detroit River Canadian Cleanup, Area of Concern, Detroit River.*

ZHOU, Y.¹ and MICHALAK, A.M.², ¹Department of Civil and Environmental Engineering, University of Michigan, Ann Arbor, MI, 48109; ²Department of Atmosphere, Oceanic and Space Sciences, University of Michigan, Ann Arbor, MI, 48109. **Estimation of Dissolved Oxygen Distribution in Lake Erie Using Geostatistical Methods.**

Hypoxia (dissolved oxygen < 2 mg/l) has been observed in the central basin of Lake Erie for many years, but its spatial extent is poorly understood due to sparse sampling. Traditional sampling techniques cannot produce detailed spatial and temporal information without large-scale measurement campaigns, which are not regularly conducted in Lake Erie. Remote sensing data have the potential of providing an abundance of data and information lacking in current field observations. The purpose of this work is to develop geostatistical data fusion methods for combining available satellite data with limited in situ measurements, and apply these methods to the estimation of the extent of hypoxia in Lake Erie over multiple years. Results show that the proposed approach produces more accurate results relative to traditional estimators such as linear regression and ordinary kriging, and can be used to accurately quantify the uncertainty associated with estimates of dissolved oxygen. Furthermore, the proposed geostatistical framework can be used to evaluate the added value of ancillary remote sensing and other data, such as depth, sea surface temperature and chlorophyll concentration. Estimates from 1998 to 2007 show that the extent of hypoxia exceeded 8000 km² in 1999, 2005, and 2007; and was lowest in 2004. *Keywords: Ecosystem modeling, Hypoxia extent, Geostatistics, Water quality, Lake Erie.*

ZHU, Y. and VODACEK, A., 54 Lomb Memorial Drive, Rochester, NY, 14623. **Investigation of the Relationship between the Thermal Bar and *Cladophora* Growth in Lake Ontario using Field and Satellite Data.**

Images from thermal satellite sensors clearly show the spatial and temporal characteristics of surface temperature distributions during the spring thermal bar period in Lake

Ontario. The satellite information combined with in situ data at Ontario Beach, Rochester, NY shows that there is a correlation with the percent of summer beach closings caused by accumulation of algae (primarily *Cladophora*) and the number of days during the spring thermal bar period when the nearshore water temperature is above 10°C. The number of days for which water temperature was greater than 10°C during thermal bar period in 2007, 2004, and 2001 were 15, 7, and 3 days, respectively. Algae accumulation contributed to 62%, 23%, and 38% of beach closings in those years, respectively. The number of days for which water temperature was greater than 10°C during thermal bar periods in 2002, 2003, 2005 and 2006 was 0 days and the impact of algae on beach closings was minimal in those years. The results of this study show that satellite observations of Lake Ontario in the spring thermal bar period can be used to demonstrate that the temperature characteristics of the thermal bar process appear to have ecological impacts extending at least into the summer. *Keywords: Remote sensing, Cladophora, Thermal Bar, Lake Ontario.*

ZHU, Y.¹, MAPUSKAR, K.², LEHMLER, H.J.², ROBERTSON, L.W.², SPITZ, D.R.¹, and AYKIN-BURNS, N.¹, ¹Free Radical and Radiation Biology Program, Departments of Radiation Oncology, University of Iowa, B180 Medlabs 500 Newton Road, Iowa City, IA, 52242; ²Occupational and Environmental Health, University of Iowa, 100 Oakdale Campus, IREH, Iowa City, IA, 52242. **Polychlorinated Biphenyl (PCB)-Induced Oxidative Stress Mediates Cytotoxicity in Human Prostate Epithelial Cells.**

PCB11 was recently found in the Chicago area air and its biological effects on human cells is relatively unknown. In the current study, exponentially growing immortalized but not fully transformed human prostate epithelial cells (RWPE-1) were exposed daily in complete serum free KSF medium to 3 uM PCB 11 and its metabolite, 4-OH-PCB11, for 5 days. The results from growth curves and clonogenic survival assays showed that the metabolite of PCB11 (4-OH-PCB11) can significantly induce cell growth suppression and decreased the plating efficiency of RWPE-1 cells. 4-OH-PCB11 was also found to significantly increase steady-state levels of intracellular O₂^{•-} (as determined by dihydroethidium oxidation) as well as H₂O₂ (as determined by oxidation of carboxy-2',7'-dichlorodihydrofluorescein diacetate). These results support the hypothesis that exposure to metabolites of PCB11 can increase steady-state levels of reactive oxygen species, inhibit cell proliferation, and cause cytotoxicity in exponentially growing human prostate epithelial cells. (Supported by NIEHS P42 ES013661)

Keywords: Environmental contaminants, PCBs, Human health.

ZIEGLER, A.H.¹, AHERN, R.G.¹, HIGMAN, P.J.², SCHOOLS, E.H.², and LANDIS, D.A.¹, ¹Michigan State University, East Lansing, MI; ²Michigan Natural Features Inventory, Lansing, MI. **The Michigan Invasive Species Information Network (MISIN): Engaging Stakeholders in Invasive Species Detection and Management.**

Invasive species threaten the sustainability of natural lands and waters, agriculture and natural resource based economies, and human health and well-being. Successfully addressing the threat of invasive species is information intensive and requires the coordinated action of multiple actors from individuals and agencies to regional and international governments. A central

problem in invasive species policy and management in the Great Lakes Region is that there is no comprehensive system to report and track new occurrences or allow multiple individuals and agencies to share data and coordinate responses. This leads to inaction or ineffective responses allowing invasive species to largely spread unabated. The Michigan Invasive Species Information Network (MISIN) is a web-based education and reporting system designed to dynamically engage and empower multiple partners to cooperate in invasive species prevention and management. At the heart of the system is a spatial database that allows real-time reporting and mapping of invasive species occurrences. These data allow immediate identification of first time occurrences (e.g. state, county and township levels) and tracking of invasion fronts at multiple scales. These data are critical to prioritizing use of limited resources and directing rapid response efforts. *Keywords: Invasive species, Monitoring, Public participation.*

ZIGAH, P.K.¹, MINOR, E.C.¹, WERNE, J.P.¹, and MC CALLISTER, S.L.², ¹Large Lakes Observatory & Department of Chemistry and Biochem., University of Minnesota, Duluth, USA, Duluth, MN, 55812, USA; ²Department of Biology, Virginia Commonwealth University, Life Sciences Building, Room 028, Richmond, VA, 23284, USA. **Sources and Cycling of Carbon in Lake Superior: Insights from $\Delta^{14}\text{C}$.**

In this study, water-column depth profiles of $\Delta^{14}\text{C}$ within dissolved inorganic carbon(DIC), dissolved organic carbon(DOC)and particulate organic carbon (POC) were used to investigate the sources and cycling of organic matter in Lake Superior,the Earth's largest freshwater lake by surface area. Radiocarbon data was obtained from western Lake Superior during periods of water-column stratification and mixing. The bulk $\Delta\text{DI}^{14}\text{C}$ (~86 to 74‰) of the stratified water column indicates DIC is in exchange with atmospheric CO₂. During stratification, the $\Delta\Delta^{14}\text{C}_{(\text{DIC-DOC})}$ for surface and deep waters (10‰ and 151‰ respectively) indicates that there may be a deep-water source of 'old' DOC. The $\Delta\Delta^{14}\text{C}_{(\text{DIC-POC})}$ of 22‰, 27‰ and 57‰ respectively for surface, mid and deep waters suggests that part of the POC pool consists of pre-aged material. The well-mixed water column reflects a modern (post-bomb) radiocarbon signal for DOC, DIC and POC across the entire sampling depth suggesting a stronger role for semi-reactive DOC in Lake Superior than in most oceans. Our $\Delta^{14}\text{C}$ data shows that organic carbon in Lake Superior consists of both labile modern and old refractory portions, and that 'old' carbon can be important to lake biogeochemistry. *Keywords: Carbon cycle, Biogeochemistry, Lake Superior.*

ZINT, M.T., Dana Building, 430 East University, Ann Arbor, MI, 48109-1115, USA.
"MEERA" - A Web-Based Resource to Support Evaluations of Great Lakes Education Programs.

My Environmental Education Resource Assistant or "MEERA" is a web-based resource that was developed to support the evaluation efforts of environmental educators including Great Lakes educators. MEERA provides an introduction to evaluation, step-by-step guidance for conducting an evaluation and a searchable database of sample evaluations, among other features. Since MEERA was officially launched in winter 2008, the site has had a growing number of visitors (currently over 4000 unique visitors from over 60 countries per month). Results from a

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

recently completed evaluation show that MEERA can successfully support the evaluation efforts of environmental educators. This presentation will explain why and how MEERA was developed, describe its main features, and share results from the recently completed evaluation of the site. At the end, participants will be asked to provide their input on how MEERA can be improved to better meet the needs of Great Lakes educators. If both presentations are accepted, this presentation will be followed by one describing the experience of a Great Lakes educator who used MEERA to evaluate one of her programs. MEERA was developed as part of a cooperative agreement between the US Environmental Protection Agency, US Forest Service, and the University of Michigan. *Keywords: Education, Environmental education, Assessments.*

Author Index

Key: **bold type**, oral presenter; *italic*, poster presenter; standard font, co-author

- Ackerman, J.D., **1**
Adams, J.M., **1**, 27, 90, 91
Adams, J.V., 209
Adlerstein, S.A., **1**, **2**
Aguilar, C., **2**, 39
Ahern, R.G., **3**, **245**
Ahmed, S., **3**
Alexander, J.F., **4**
Alexandrou, N., 216
Ali, A.K., **4**
Alvarez, D.A., 217
Ames, A., 42
Amos, M.M., 92
Anderson, E.J., **4**, 239
Anderson, H.A., 219
Anderson, J.D., 130, 238
Anderson, M., 93
Angel, J.R., **5**
Anstead, A.M., 172
Anyanwu, E., 99
Applegate, J., 23
Arbogast, A.F., **5**
Arceo, A.I., 75
Archbold, J.A., 46
Arend, K., **6**
Argyilan, E.P., 105, 218
Arhonditsis, G.B., 175, 182
Armenio, P.M., 48, 190
Armitage, D., 205
Arts, M.T., 21, 105
Ashton, D.M., **6**
Aspinall, J.D., 70
Atilla, N., **7**, 150, 222
Atkinson, J.F., 56, 162, 173
Auer, M.T., 47, 219
Ault, S., 149
Ault, T., 42
Austin, J.A., 233
Awad, E., 14, 69
Aykin-Burns, N., 245
Bach, C.A., **7**
Backus, S., 15, 45, 126, 157, 163, 188
Bade, D.L., 35
Baedke, S.J., 105, 218
Bai, X., **8**, 228
Bajc, A.F., 8
Baker, C.L., **9**
Baker, D.B., **9**, 108
Balcer, M.D., 11
Baldwin, R., 71, 72
Ballard, M.M., 146
Balshine, S., 141
Banda, J.A., **10**
Banic, C.M., 43, 163
Bantelman, A., **10**
Barber, D.G., 148
Barbiero, R.P., **11**
Bariteau, L., 160
Barker, N., 33
Barnswell, K.D., 53, 190
Barton, C.C., 203, 204
Barton, D.R., 169
Barton, N.T., **12**
Basiliko, C., 56, 173, 174
Baskaran, M., 169
Basu, I., 91
Basu, N., **12**, 87
Bateman, J.D., 200
Bates, S., 224
Becker, R.H., **13**
Beletsky, D., 6, **13**, 98, 192, 214
Bellamy, S.R., 142
Bence, J.R., 48
Benitez-Nelson, C.R., 99
Bennett, L., 70, 71, 72
Bennington, V., 7, 150, 222
Berges, J.A., 58, 83
Berquist, M., 165
Bertram, P., 64, 195
Bhavsar, S.P., **14**, 69
Biddanda, B.A., 38, 169
Bidleman, T.F., **15**
Bills, T., 185
Binkowski, F., 58

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

- Björck, S., 82
Black, G.M., 44
Blair, C.A., **15**
Blanchard, P., 43, 188
Blasco, S.M., 147
Blatz, C.V., **16**
Blenckner, T., 161
Blockstein, D.E., 65
Blosser, J., 16
Boase, J., 140
Bocaniov, S.A., **17**, 207
Bodamer, B.L., 17, 35
Boehme, S.E., 27, 90
Bogue, M., 18
Bohrer, J., 114
Bolen, W.J., **18**
Bollin, T., 18
Boltovskoy, D., 25
Booth, C., 89
Bootsma, H.A., **19**, 63, 83, 168
Booty, B., 206
Boscarino, B.T., **19**
Bossenbroek, J.M., **20**, 38, 139, 145
Bostan, I.V., 147
Boston, T.J., **20**
Bourbonniere, R.A., 42
Bourland, D., 21
Bowen, K.L., **21**, 69, 241
Bowerman, W., 225
Bowser, P.R., 79
Boyd, D., 14
Boyer, G.L., 13, **22**, 56, 139, 173, 231
Bradford, A., 224
Bradley-Macmillan, C., 205
Braig, E.C., **22**, 23
Branfireun, B., 215
Braucher, S.R., **23**
Breckenridge, A.J., **24**
Brice, K.A., 216
Bridgeman, T.B., 17, 30, 134, 139
Briggs, T., 243
Brigham, S., 114
Bristol, C., 154
Brofka, W.A., 39
Brooking, T.E., 63
Brousseau, C.M., 183
Brown, J.E., **24**, 110, 211
Brown, L., 25
Brown, S.B., 54, 55, 201
Buan, S.D., 198
Buchsbaum, A., 67
Budd, J.W., 237
Bullerjahn, G.S., 42, **99**, 156
Bunnell, D.B., 11, 170
Bur, M.T., 180
Burlakova, L.E., **25**, 109, 145
Burt, A., 8
Burton, G.A., 41, 109
Bushkin, S.C., **26**
Butterworth, F.M., 26
Cabrera, S.C., 27
Cagampan, S.J., 15, 77
Cai, G., 74
Campbell, L.M., **27**, 112, 126, 165, 181
Campbell, M., 21, **27**
Cargnelli, L., 243
Carlock, M.M., 167
Carlson, D.L., 184
Carlson, M., 234, 235
Carpenter, D.O., 26
Carreon-Martinez, L.B., **28**
Carrick, H.J., **28**, 42, 124
Casey, C.M., 148
Casey, J.W., 79
Casey, R.N., 79
Castaneda, M., **29**
Cataldo, D., 25
Cattaneo, A., 231
Cavaletto, J.F., 29, 225
Chaffin, J.D., **30**
Chambers, E., 1
Chan, E., 216
Chapman, K., **30**
Chapra, S.C., **31**
Cheng, S.T., **31**, 234, 235
Child, M., 183
Choc, S.J., **32**
Choi, H.D., **32**
Cholger-Blust, S., **33**
Chu, C., 50
Ciborowski, J.J., 33
Clapsadl, M., 56, 174

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

- Claramunt, R.M., 12, **34**, 106, 229
Clemens, L., **34**
Clevinger, C.C., **35**
Clites, A., 98, 228
Coblentz, S., 114
Cole, P., 35
Collingsworth, P.D., **36**, 165
Collins, N.C., 160
Colman, S.M., 186
Conroy, J.D., **36**, 56, 108
Consi, T.R., 83
Cook, H.A., 36
Corkum, L.D., **37**
Correa, P.A., **37**
Corry, T.D., 112
Cory, R.M., 177
Cotner, J.B., **38**, 177
Craig, J.M., 44, 113
Craig, J.R., 107
Crail, T.D., 16, **38**, 75, 76, 145, 199
Crane, T.R., 38
Crawford, E.L., 178, 235
Creque, S.M., **39**, **208**
Croley, T.E., 86
Csiszar, S., 188
Cuhel, R.L., 2, **39**
Culler, B.M., **40**
Culver, D.A., 36, 94, 108
Custer, K.W., 41
Cuthbert, F.J., 41
Czajkowski, K., **42**
Czesny, S.J., 39, 208
da Silva, S., **201**
Daggupaty, S.M., 43
Dai, Q., **43**
Daley, B.A., **44**, 191
Daniels, C., 139
Dassey, T.W., 136
Date, K., **44**
Daunys, D., 242
David, D.W., 187
Davis, M., 61
De Boer, D., 61
De Silva, A.O., **45**
De Tezanos Pinto, P., **45**, 132
DeBofsky, A., 87
Del Gobbo, L.C., 46
DeMarche, C.J., 207
DeMarchi, C., 43, **46**, **86**, 103
Deng, Y., 98
Depew, D.C., **47**, 129, 169
DePinto, J.V., 6, **47**, 184, 192, 226
Deroba, J.J., **48**
Desai, A., 7, 150, 222
DeVanna, K.M., **48**, 101, 204
Diamond, M.L., **46**, 67, **188**
Diggins, T.P., **49**
Dillon, P.J., 168
Dobiesz, N.E., **49**
Dobson, T.A., 151
Doka, S.E., **50**, 160
Dolan, D.M., 31, **50**
Dombkowski, A., 98
Domske, H.M., **51**
Dong, N., **51**
Donnelly, K.A., **52**
Dorman, L., 23
Doss, M., 103
Dove, A., 15, 31, **52**, 126, 230
Drake, D.A.R., **53**
Drelich, A., 170
Drouillard, K.G., 103, 110, 111, 121
Drouin, R., 70, 243
D'Souza, N., 42
Duncan, A.M., 53, 190
Dunlop, E.S., **54**
Dunn, G., 70
Dussault, E.B., 54, **55**, 201
Dvonch, J.T., 78
Dwyer, D.F., 32, 53
Dyble Bressie, J., **55**, 154, 214, 239
Eadie, B.J., 86
Eagles, P.F., 233
Eastling, P.M., 189
Eberhardt, R.A., **55**, 67
Eckerlin, G.E., 79
Eckley, C., 46
Eckman, D., 74
Eder, T.A., 72
Edge, T., 206
Edney, E.O., 167
Edwards, W.H., 180

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

- Edwards, W.J., 10, 51, **56**, 139, 173, 196
Effler, S.W., 166, 175
Egan, K.J., **57**
Eglite, E., **57**
Eklöv, P., 161
Ellison, R., 121
Ellrott, B.J., 106
Elmer, H., 40
Emmenegger, E., 58
Engbers, H., 157
Engevoold, P.M., 58
Erdman, N.R., 189
Escobar, I., 74
Estenik, J., 59
Evans, L.E., 59
Evans, M.A., **60**, 132
Evans, M.S., **60**, **61**
Ewert, D.N., 41
Fahnenstiel, G.L., 55, *61*, 154, 180, 225
Fairall, C.W., 160, 192
Faisal, M., **62**, 114
Fanslow, D.L., 161
Farrell, J.M., 79
Fellin, P., 216
Fenichel, E.P., **62**, 137
Fetters, K., 41
Fetzer, W.W., **63**
Fielder, D.G., 100
Fillingham, J.H., 19, **63**
Finlayson, P.H., **64**
Finnell, E.H., 217
Finnoff, D., 20, **82**, 230
Fischer, A., 174
Fisher, T.G., 24, 27, 29, **64**, 82, 119, 134, 135
Fisk, A.T., 80
Fitzpatrick, M., 158, **159**
Fitzsimons, J.D., 12, 93, 106
Flanagan, M.M., **65**
Fletcher, R., 14, 69
Florence, L.W., **65**
Focht, W.J., **65**
Forman, S.L., 5
Forney, J.L., 63
Fortner, R.W., **66**, **185**
Francis, J.T., **66**
Frantz, J., 190
Fratta, C., 131
Frattini, S.E., 79
Fryer, B.J., 141
Fugate, E.J., **67**
Fuller, J.A., 119
Fung, S., 139
Funke, M.M., 177
Furlong, E.T., 217
Futter, M.N., 168
Gabriel, T.A., **23**
Gaden, M., **67**
Gagnon, L., 171
Galarneau, E., **67**, **68**
Galarowicz, T.L., 12
Gamble, A.E., **68**
Gannon, J.E., **68**
Garraway, M., 224
Gerlofsma, J., 21, **69**
Getchell, R.G., 79
Gewurtz, S., 14, **69**
Gharabaghi, B., **25**
Giang, A., 188
Gibson, J.L., 22
Giesy, J.P., 107, 164
Gilbert, B., 188
Gilbert, J.M., **70**
Gilbride, K., 147
Gillingham, J.C., **71**
Ginn, B.K., **71**, **72**
Glassner-Shwayder, K.M., **72**
Glover, D.C., 208
Goble, R.J., 27, 29, 135
Goettel, R.G., 81, 90
Goetz, F.R., 190, 206
Goetz, R., **58**
Gogineni, P., **73**
Gomezdelcampo, E., 73
Gondwe, M., 79
Gooderham, K.L., 141
Gorey, C., **74**, 118
Gorman, O.T., **75**, 190
Gorr, M.W., 53
Gosman, S.R., **75**
Gottgens, J.F., 38, 53, **75**, 199
Grabarkiewicz, J.D., 76

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

- Grabas, G.P., **76**, 232
Grabuski, J.M., **77**
Graham, A., 205
Gramley, J., 1
Granados, M., **77**
Grapentine, L.C., **78**
Gratz, L.E., **78**
Greccay, P.A., 187
Green, N.D., **243**
Greil, R., 210
Griffis, V.W., 146
Grigorovich, I., 24
Groocock, G.H., **79**
Grubb, C., 67
Gruden, C.L., 74, 134, 153
Gudimov, A., 182
Guildford, S.J., 47, **79**, 180
Gunn, M., 62
Guo, J., **80**, 171
Guzzo, M.M., **80**
Gyawali, R., 146
Haas, R.C., 33, **80**
Haffner, G.D., 80, 110, 111, 243
Haight, R.G., 94
Hale, S., 59
Hallesy, T.E., **81**
Hambusch, G., 82
Hamilton, K., 126
Hansen, E.C., **82**
Hansen, M.J., 190
Hansen, T., 83
Hanson, A.M., **83**
Haponski, A.E., 18, **84**
Harkness, M., 41
Harrison, J.W., **84**
Hart, D.A., **85**
Hartzog, P.E., **85**
Harvey, H.H., 53
Hatt, C.R., **86**, 202
Haughwout, M., 219
Hawley, N., 28, **86**, 98
Hayton, A., 14
He, C., 86, 103
Head, J.A., 87
Heath, D.D., 28, 127
Heath, R.T., 35, 237
Heath, W.T., 79
Heckathorn, S.A., 30, 190
Hecky, R.E., 47, 79, 169, 180
Hedges, K.J., **87**
Helm, P.A., 14, 188
Hensgen, J., 2
Hensler, S.R., **88**, 107
Heppner, E.A., 145, 199
Hermanson, J.C., **88**
Herr, H., 114
Hershey, K.M., 85
Hesseltine, D., 1
Hewitt, M.L., 201
Hickling, G.J., 62
Hicks, R.E., **89**, 115
Higgins, S., 129
Higgins, S.N., 47, **89**
Higman, P.J., 245
Hill, R.B., **90**
Hinchey Malloy, E.K., 1, 27, **90**, **91**
Hipsey, M.R., 129, 207
Hiriart-Baer, V., 183
Hites, R.A., **91**, 163, 194, 225
Hodson, P.V., 165
Holeck, K.T., **91**, 193
Holman, K.D., 128
Holsen, T.M., 32, 68, 92, 155
Holub, B., **93**
Homans, F.R., 94
Honeyfield, D.C., **93**, 207
Hood, J.L.A., 93
Hook, T., 6, 17
Höök, T.O., 100, 187
Hope, K.M., 79
Hopke, P.K., 32, 92, 155
Horan, R., 137
Horie, T., **94**
Horn, J.D., **94**
Hornbuckle, K.C., 97, 140, 143, 176, 189
Horst, G.P., **95**
Horvatin, P.J., 1, 122
Houben, A., 47, 169
Houghton, C.J., **95**
Howell, E.T., 156
Howell, T., **96**
Hoyle, J.A., 105

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

- Hrabik, T.R., 68, 100
Hsieh, Y.F., **96**
Hu, D., 37, **97**, 143
Hu, H., 97, **98**
Huang, A., 240
Huang, X.L., **98**
Hudder, A., 98
Hudon, C., 231
Hummel, S., 41
Hung, H., 216
Hunkins, K.L., **99**
Hunter, D., 33
Hunter, T.S., 46
Huntley, M., 40
Hyde, R.D., 64
Hyndman, D., 113, 179, 222, 234, 235
Hynes, H., 141
Ilikchyan, I.N., 99
Imm, P., 219
Isaac, E.J., 21, **100**, 112
Ivan, L.N., **100**
Iverson, L.R., 20
Jackson, D.A., 69, 77
Jackson, J.R., 63, 193
Jacobs, D., 70
Jain, N., *101*
Jamu, D., **101**
Janecek, K., 26
Janik, C.P., 174
Janssen, J., 95, **102**, 181, 228
Jantunen, L.M., 15
Januska, B., 73
Jaoui, M., 167
Jenkins, L.K., **102**, 202
Jensen, E.S., 72, **103**
Jentes Banicki, J., 40
Jezdic, I., **103**
Johannsson, O.E., 87, 112
Johansen, J.R., 135
Johengen, T.H., 86, **103**
Johnson, J.A., 88
Johnson, J.E., **104**
Johnson, R., 190
Johnson, T., 28, 50
Johnson, T.B., **105**, 112, 127, 241
Johnston, C.A., 201
Johnston, J.W., **105**
Jonas, J.L., **106**
Jones, A., **106**
Jones, E.L., **107**
Jones, M.L., 62
Jones, P.D., 164
Josberger, E., 202
Joseph, S.T., **107**, 214
Jude, D.J., 88, **107**, 153
Jungbluth, L., 28
Just, C.L., 37
Kane, D.D., **108**
Kania, P.A., 85
Kanivetsky, R., 177
Kapo, K., 109
Karatayev, A.Y., 25, **109**, 145
Karatayev, V.A., 25
Karsiotis, S.R., *110*
Kashian, D.R., **110**, **111**, 121
Kayle, K., 36, 174
Keating, J., 60, 61
Keeler, G.J., 78
Kelch, D.O., 136
Kellogg, W.A., **111**
Kelly, J.R., **112**, 242
Kelly, M.D., **112**
Kelly, R.I., **8**
Kendall, A.D., **113**, 179, 234, 235
Kennedy, G.W., 44, **113**, 140
Khan, I., 206
Kick, T., 114
Kiger, S., *114*
Kilbert, K.K., **114**
Kilgour, B., 72
Kim, R., 62, **114**
Kimura, N., 150
Kingston, M., 205
Kinkead, J., 142
Kish, J.L., 89, *115*
Klarer, D.M., 61, 154
Klausmeier, C.A., 60, 132
Klecka, G.M., 176
Kleindienst, T.E., 167
Kling, H.J., 148, 158, 159
Klump, J.V., 83, **115**, **116**, *169*, 229
Knapp, J.L., 119

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

- Knight, R.L., 36
Knobeloch, L.M., 219
Kobus, D.L., **116**
Koches, J., 234, 235
Kocovsky, P.M., **117**
Koehler, N., **117**, 213
Kolinski, C., 74, *118*
Koltun, G.F., 217
Koops, M.A., 50, 87
Korosov, A.D., 202
Korwel, I., **118**
Koslow, M.R., *119*
Kovalak, W.P., 200
Kowalski, K.P., **119**
Krakauer, N.Y., 201
Kramer, J.W., 9, 189
Krantz, D.E., **119**, 213
Krantzberg, G., **120**
Kraus, D.T., 41, **121**
Krause, A.E., 110, 111, **121**, 220
Kreis, R.G., **122**, 243
Krieger, K.A., 196, 236
Kristovich, D., 205
Krueger, D.M., **122**
Krutsch, D., 140
Kunkel, K.E., 5
Kurath, G., 58
Kurt, P., 157
Kurt-Karakus, P.B., 15
Kusnier, J., **123**
Labencki, T.L., 14
Ladewig, M., 234
Lafrance, P., 149
Lamb, K.G., 132
Land, M.D., **123**
Landis, D.A., 245
Landis, D.L., 3
Lang, G.A., 4
Langen, T.A., **124**
Laprise, R., 143
Lashaway, A.R., **124**
Laubender, B.G., 236, 240
Laursen, A., 147
Lavelle, K.M., *125*
Law, P., 139
Lawrence, P.L., **125**
Lawrence, T.J., 49, **125**
Lawson, G., 126
LeBlond, S.S.M., **126**
Lee, C.E., 178
Lee, P.F., **127**
Lee, R.E., 236, 240
Legler, N.L., **127**
Lehmler, H.J., 245
Lekki, J.D., **128**
Lenters, J.D., **128**
Leon, L.F., 107, **129**, 207
Lepper, K., 105, 218
Leshkevich, G.A., 98, 128, **129**, **165**, 166,
175, 202
Lesht, B.M., 11
Letourneau, F., 70
Lewandowski, M., 167
Lewis, C.F.M., 147
Lewis, T.W., 56, 139, 173
Li, J., 1
Liao, Q., 96, **130**
Lichtkoppler, F., 40
Liebig, J.R., **130**, 225
Limburg, K.E., 131
Lin, L., 139
Lin, Y.T., **131**
Litchman, E., 45, 60, **132**, 218
Liu, S., 129
Liu, W., **132**
Liu, Z., 121
Liukkonen, B., **132**
Livengood, A., 114
Locke, B., 70
Lockhart, W.L., 61
Lodge, D., 230
Lofgren, B.M., **133**
Lohner, R.N., 110, **134**
Longton, G.D., 200
Loomer, H., 96
Loope, H.M., 135
Loope, W.L., 29, **135**
Lougheed, V.L., 212
Lovis, W.A., 5
Lowe, A., 114
Lowe, R.L., **135**
Lowell, T.V., 24

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

- Lowes, C.I., 136
Lozano, S.J., **136**
Lu, X., 20
Lu, Y., 240
Lucente, J.E., **136**
Luckey, F., 155
Ludsin, S.A., 6, 28, 36, 127, 170, 187
Lupi, F., **137**
Luzadis, V.A., 131
Ma, J., 137
MacDonald, E., 138
MacKay, M.D., **138**
Macuiane, M.A., 79
Madenjian, C.P., 225
Mailkin, S., 129
Maitre, M., **139**
Makar, P.A., 67
Makarewicz, J.C., 56, **139**, 173, 174
Malkin, S.Y., 47, 169
Mandrak, N.E., 53, 77, 87
Manley, T.O., 57, 99
Manninen, C., 103
Manning, N.F., **139**
Manno, J., 120
Manny, B.A., 44, 113, **140**
Manny, B.M., 183
Manzo, L., 40
Mapuskar, K., 245
Marek, R.F., **140**
Marentette, J.R., **141**
Markham, J., 174
Marklevitz, S.A.C., **141**
Marschall, E.A., 36, 165
Marsden, J.E., 106
Marshall, A.M., 142
Marshall, G., 147
Martin, P.J., **142**, 224
Martinez, A., **143**
Martin-Hayden, J., 27
Martynov, A., **143**
Maruthi Sridhar, B.B., 144
Marvin, C.H., 14
Mason, D.M., 122
Masson, C., **144**
Mastitsky, S.E., 109, **145**
Mathias, P.M., 38
Mathias, P.T., 145, 199
Matisoff, G., 10, 125, 196
Matsumoto, K., 233
May, J.C., 1
Mayer, A.S., **146**
Mayer, C.M., 48, 101, **131**, 139, 197
Mc Callister, S.L., 246
McAndrews, J.H., 147
McCammon, A.J., **146**
McCarthy, A.J., 178
McCarthy, F.M.G., **147**, 164
McCarthy, L.H., **147**
McCormick, M.J., 162
McCullough, G.K., **148**
McDonald, C.P., **148**, 222
McDonald, E.A., 149
McEachern, P., 61
McElmurry, S., 154
McGrath, K.J., **149**
McKay, R.M.L., 42, 99
McKinley, G.A., 7, **150**, 222
McKinney, T., **150**
McMaster, M.E., 54, 55, 141, 170, **201**
McNally, A.M., 177
McNaught, A.S., **149**
McNeill, K.P., 177
Meadows, G.A., 166, 202
Meadows, L.A., 166
Meggo, R.E., **150**
Melendez, W., 122, 172
Mello, M.E., 46
Melymuk, L.E., 188
Mentzer, G.C., 173
Mercader, R.B., **151**
Mergler, D., **151**
Merrifield, L., 90
Mersereau, J., 1
Messervey, R.W., **152**
Meunier, B., 37
Meyer, M.T., 217
Meyer, N., 132
Meyer, P., 224
Micacchion, M., **152**, 209
Michalak, A.M., 244
Mida, J.L., **153**
Mileyeva-Biebesheimer, O., 18, 153

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

- Millard, E., 62, 114
Miller, B.K., 90
Miller, C., **154**
Miller, D.H., 239
Miller, K.M., 92
Miller, S.E., 112, 242
Millie, D.F., **154**
Milligan, M.S., 32, **92**, 155
Mills, E.L., 91, 109, **155**, 231
Milne, S.W., 54
Milz, S., 157
Miner, G.H., 156
Miner, J.G., 135
Minniefield, C., 73
Minor, E.C., 246
Minson, M.A., 19
Mkumbo, O.C., 49
Mo, W., 146
Moerke, A.H., 210
Mohamed, M., **156**
Molloy, D.P., 145
Monaghan, G.W., 5
Moody, R., 14, 69
Moorehead, N., 196
Moorhead, D.L., 134, **157**
Morbey, Y.E., 141
Morton, W.B., 72
Mortsch, L., 224
Moss, M.R., **157**
Mugalingam, S., 20
Muir, D.C.G., 15, 45, 54, 60, 126, **157**
Muirhead, J.R., **158**
Mulchansingh, K., 224
Munawar, I.F., 158
Munawar, M., 112, 155, **158**, 159
Murphy, E.W., 92, 122
Murphy, S.C., **160**
Murray, M., 67
Murray, M.W., 119
Mwangi, J.M., **160**, 222
Mysorekar, S., 41
Naddafi, R., **161**
Naile, J., 164
Nalepa, T.F., 28, 61, **161**, 196, 225
Nedunuri, K.V., **162**
Nekouee, N., **162**
Nelson, H., **163**
Neruda, J.A., 200
Nettesheim, T.G., **163**
Nettleton, P., 156
Neville, L.A., 164
Newsted, J.L., **164**
Nghiem, S.V., 165
Ngochera, M., 79
Niblock, H., 158, 159
Nicholas, J.R., 199
Nieber, J.L., 177
Nikolaidis, N., 208
Nims, M.K., 85, **165**
Nold, S., 169
Norman, S.A., 85
Norris, K.D., 165
Norstrom, A.K., 140
Norton, A.N., 119
Norton, R.K., **166**
Nowell, B., 121
Nussbaum, M., 114
O'Brien, T.P., 191
O'Donnell, D.M., **166**
Offenberg, J.H., 167
O'Gorman, R., 91
O'Keefe, J., 107
Olenin, S., 242
Olesik, J.W., 165
Olson, W.J., **168**
O'Meara, J.M., **167**
Oni, S.K., **168**
Orchard, A., 155
Orlandini, K.A., 229
Ortiz, J.D., 4, 237
O'Shea, K.E., 98
Oster, R.J., 89, 115
Ostrom, D.E., 89
Ozersky, T., 47, **169**
Paddock, R., 169
Padilla, D.K., 109
Pagano, J.J., 32, 92, 155
Page, S., 80
Palm, S., 237
Pangle, K.L., **170**
Park, R., 163
Parrish, D.L., 203

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

- Parrott, J.L., 55, 141, **170**, 201
Pascoe, T., 171
Paskauskas, R., 242
Patterson, K., **171**
Patterson, R., **172**
Pauer, J.J., **172**
Pavlac, M.M., 56, 173
Payne, J.F., 202
Pearce, C., 147
Pearson, B.A., 173
Pearson, R.A., **38**
Pebbles, V.I., **173**
Penamon, W.A., 173
Pennuto, C.M., 51, 56, 139, 173, **174**, 193, 241
Perez-Fuentetaja, A., **174**
Perhar, G., **175**
Perkins, M.G., **175**
Perlinger, J.A., 160, 192, 222
Pernica, P., **176**
Persoon, C.L., **176**
Peterson, B.M., 177
Peterson, H.M., 177
Peterson, K.A., 163
Pettersson, K., 161
Peyer, S.M., 88, **178**
Pick, F.R., 221
Pientka, B., 203
Pierce, L.R., **178**
Pijanowski, B.C., 113, **179**, 183, 187, 212, 222, 234, 235
Plain, R., **179**
Pope, A.J., 85
Porta, M.J., 180
Poste, A.E., **180**
Pothoven, S.A., 29, 61, **180**, 187, 225
Poulopoulos, J., **181**
Pozdnyakov, D.V., 202
Proctor, M.E., **181**
Qiao, S., 215
Quaring, G.F., 166, 175
Quilliam, M., 231
Quinn, F.H., **182**
Rachwal, J.C., 200
Ramin, M., **182**
Ramsey, M., 131
Randall, R.G., 50, **183**
Ray, D.K., 113, 179, **183**
Read, J.G., **183**, **184**
Redder, T.R., 47, **184**, 226
Rediske, J.D., 185
Rediske, R.R., 107, **185**
Redman, R.A., 39
Reeves, H.W., **199**
Reichert, J., 170
Reiner, E.J., 14, 69
Reutter, J.M., 22, 185
Reznicek, A.A., 3
Richards, P., 234, 235
Richards, R.P., 9, 108
Richardson, V., 96, 112, 214
Ricketts, R.D., **186**
Ridal, J., 165
Riddle, C.M., 40, **186**
Ridgway, M.S., 54
Ripple, S., 28
Rise, M., 181
Riseng, C.M., **187**, 212, 222, 234, 235
Robbins, J., 196
Roberts, J.J., **187**
Roberts, P.J.W., 162
Robertson, L.W., 245
Robson, M.E., 188
Rodenburg, Z.L., 189
Rodgers, G., 20
Roebber, P.J., 63
Roerdink, A., **189**
Rofkar, J.R., 53, 190
Rook, B.J., **190**
Rosauer, D., **190**
Rose, J.B., 226
Roseman, E.F., 44, 149, **191**
Rossmann, R., 122, 172, **191**, 243
Rothlisberger, J.D., 230
Rowe, M.D., **192**
Ruberg, S., 169
Ruch, R.J., 17
Rucinski, D.K., 6, 47, **192**
Rudra, R., 20
Rudstam, L.G., 19, 63, 91, **193**, 203, 231
Rupprecht, S.M., **193**
Rutherford, E.S., 122, **194**, 222, 234, 235

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

- Rutherford, S., 142
Rutter, A., 126
Rygwelski, K.R., 122, 243
Salamova, A., **194**
Sanderson, L.M., 73, 194
Sandgren, C.D., 58
Sandren, C.D., 58
Sano, L., 121
Sano, L.L., 110, 111
Sarnelle, O., 55, 95
Sass, D.J., **195**
Satchell, E., 146
Satchwell, M.F., 22
Sathyanarayan, A., 94
Scavia, D., 6, 61, 153, 192
Schaeffer, J.S., 104, 153, 209, 229
Schafer, J.S., 19
Schaner, T., 241
Schantz, S.L., **195**
Schardt, J.C., 18
Scharold, J.V., 112, 136
Schauer, J.J., 167
Schemske, D.W., 3
Schiff, S.L., 17
Schlekat, C., 41
Schloesser, D.W., 10, 33, 101, **196**, 200, 236, 240
Schmid, M., 238
Schnars, J.L., **197**
Schnoor, J.L., 150
Schnoor, J.S., 208
Schools, E.H., 245
Schultz, C., 62
Schulz, K.L., 91, 131, **197**
Schwab, D.J., 4, 6, 13, 98, 162, 192, **198**, 214, 239
Scofield, J.A., 92
Seegers, B.N., **198**
Seelbach, P.W., 199, 234, 235
Seger, T., 74
Seidel, W., 132
Selden, J.D., 199
Sepulveda Villet, O.J., 84, **200**, 236
Seymour, M.M., **41**
Shackelford, M.T., **200**
Shaffer, S., 82
Shaskus, M., **59**
Shavalier, M., 114
Shear, H., 201
Sheesley, R.J., 167
Sherman, R.K., **33**
Sherry, J.P., **54**, 55, 201
Shmagin, B.A., 177, **201**
Shogren, J.F., 230
Shuchman, R.A., **202**
Sideleva, V., 102
Siedlaczek, B.B., 167
Sieggreen, D., 117
Silsbe, G.M., 47
Silverman, E., 2
Simoliunas, S., **26**, 73
Simonin, P.W., **203**
Simpson, K.E., **203**
Singler, K., 204
Sitar, S., 190
Slaats, J., 41
Slade, J., 2
Slater, G.F., 141
Slavik, E., 70
Sloss, B.L., 181
Small, J., 15, 45
Smigelski, J.R., 204
Smith, E.C.P., 77
Smith, E.R., 27
Smith, J.L.H., 189
Smith, J.S., 22
Smith, M., 59
Smith, P.G.R., **205**
Smith, R.A., **205**
Smith, R.E.H., 17, 47, 84, 107, 129, **207**
Smith, T., 206
Smith, T.T., 173
Smithers-Peart, T.A., 206
Snyder, F.L., **206**, **207**
Snyder, R.J., **207**
Sobaski, S., 41
Soster, F., 10, 196
Spaulding, B., 163
Spillman, C.M., 207
Spitz, D.R., 245
Spongberg, A.L., 119, 237
Sritharan, S.I., 162

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

- Stadler-Salt, N., 64, 195
Stainbrook, K.M., 208
Stainton, M.P., 148
Stamati, F., **208**
Stapanian, M.A., **209**
Steen, P.J., **209**, 234, 235
Steinhart, G.B., **210**
Stepien, C.A., 10, 18, 24, 84, 110, 134, 178,
200, 206, **210**, **211**
Sterner, R.W., 198, **211**
Stevenson, R.J., 187, **212**, 234, 235
Stewart, K.M., 24, **212**
Stewart, S., 117, **213**
Stierman, D.J., 21, *213*
Stockwell, J.D., 68, 100, 112
Stosic, A., 141
Stow, C.A., 103, **213**, 225
Strait, C.M., 166, 175
Struger, J., 15, 77, 171, *214*
Stumpf, R.P., **214**, 239
Stupple, G.W., **215**
Sturtevant, R.A., **142**, **215**
Su, K., 216
Su, Y., **216**
Sullivan, P.J., 203
Sultan, M.I., 13
Sushama, L., 143
Sverko, E., 15, 216
Swackhamer, D.L., 184
Swartz, K., **216**
Sweeney, S.J., 70
Swinehart, C.Y., **217**
Sylvester, F., 25
Szwec, J., 165
Taleban, V., 25
Tao, H., 184
Taulbee, K., 41
Taylor, K., 1
Taylor, W.D., 93
Tebbens, S.F., 204
Teisan, J., 213
Teixeira, C., 15, 157
Tertuliani, J.S., **217**
Tetreault, G.R., 170
Thoemke, J.D., 177
Thomas, M.A., 56
Thomas, M.K., *218*
Thomas, M.V., 100
Thomas, S.P., 56, 173
Thompson, P., 142
Thompson, T.A., 105, **218**
Thorne, P.S., 140
Tillitt, D.E., 93
Tinkler, K.J., 164
Tloczynski, K., **219**
Tomasallo, C.D., **219**
Tomlinson, L.M., **219**
Tomlinson, M.C., 214, 239
Tomy, G., 46
Tonto, J.F., **138**
Torbick, N.M., 220
Toth, C., 201
Townes, G., 80
Tramer, E.J., **220**
Troy, C.D., 3
Tsao, J.I., 62
Tupling, J., 224
Turner, C.L., 184
Turyk, M.E., **221**
Twiss, M.R., 13, 42, 124, **221**
Tyler, J.A., 122, **222**, 234, 235
Tyson, J., 139
Tyson, J.T., 36
Ulrich, C., 221
Urban, N.R., 7, 148, 150, 160, **222**
Uzarski, D.G., 71
Vail, J.H., **223**
Valentine, L., 155
Valiante, M., **223**
Van Aken, B., 37
Van Alstine, J., 242
van Dijk, D., **224**
Van Tassell, J.J., 165
Van Vliet, D.J., 142, **224**
Van Zoest, P., 40
Vander Zanden, M.J., 89
Vanderlinden, L., 46
Vanderploeg, H.A., 55, 61, 130, 180, 187,
225
VanDeValk, A.J., 63
Vedejs, C., 1
Venette, R.C., 94

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

- Venier, M., 91, 163, **225**
Venkatesh, S., 137
Verhamme, E.M., 47, **226**
Verhougstraete, M.P., 226
Vigmostad, K.E., 41
Villeneuve, M.J., **227**
Vincent, R.K., 144, 162, 194, **227**
Vincent, S.G., 65
Vodacek, A., 244
Vodika, T., 114
Vogel, J., 1
Walker, R., 224
Wallat, G.K., **227**
Walsh, P.J., 98
Walters, H., 90
Walters, M., 25
Waltz, A.R., 32
Wang, J., 8, 97, 98, 128, **228**
Wang, X., 60, 157
Wang, Y., **228**
Waples, J.T., 115, **229**
Warner, D.M., 153, **229**
Warren, G.J., 1, 11, 31, 52, 122, **230**
Warziniack, T., **230**
Watkins Jr., D.W., 146
Watkins, J.M., **231**
Watson, S.B., 80, 171, 206, 214, **231**
Watton, J.P., **232**
Weckman, G.R., 154
Weeks, C., 114
Weinert, M.E., 223
Weisener, C., 242
Welch, J., 89
Wells, J., 177
Wells, M.G., 176
Wendt, D.P., **232**
Werne, J.P., 89, 115, 246
West, D.C., 63
White, B.A., 233
White, G.A., 41, 121
White, K.E., 63
Whitelaw, G.S., **233**
Wierda, M., 225
Wilbarger, J., 133
Wilcox, D.A., 105, 218
Wiley, M.J., 31, 122, 187, 209, 212, 222, **234, 235**
Wilhelm, S.W., 42
Willey, J.C., 178, **235**
Williamson, M., 45
Wilson, J.Y., 141
Wilson, W., 236
Winslow, C.J., 85
Winston, G.W., **236, 240**
Winter, J., 25
Winters, A., 62
Wires, L.R., 41
Witter, D.L., 4, **237**
Witter, J.D., 237
Wolfe, E., 26
Wolin, J.A., 219
Woller-Skar, M.M., 135
Wooster, G.E., 79
Wu, C., **237**
Wu, C.H., 7, 96, 130, 131, 150, **238**
Wuest, A., **238**
Wynne, T.T., 214, **239**
Xia, M., **239**
Xia, X., **239**
Yavno, S., 37
Yerubandi, R., 80, 96, 129, 171, 206, **240**
Yi, S.X., 236, **240**
Yoshiyama, K., 60
Young, B.T., **241**
Young, E.B., 83, **136**
Young, W.A., 154
Yu, S.Y., 24
Yuille, M.J., **241**
Yule, D.L., 68
Yurista, P.M., 112, **242**
Zaiko, A., **242**
Zaky, A., 74
Zastepa, A., 221
Zaugg, S.D., 217
Zhang, L., **242**
Zhang, Q., 146
Zhang, W., 182
Zhang, X.I.N., 122
Zhang, X.M., 122, **243**
Zhao, J., 240
Zhao, Y., 107

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

Zhou, H., 243
Zhou, Y., **244**
Zhu, Y., **244, 245**
Ziegler, A.H., 245

Zigah, P.K., **246**
Zimmerman, J.B., 67, 146
Zint, M.T., 65, **246**

Keyword Index

3-D modelling, 8
Aboriginal, 106
Acipenser fulvescens, 149
Acoustics, 54, 230
Africa, 79, 125, 180, 238
Agricultural run-off, 74
Agriculture, 205
Air quality model, 67
Air-water interfaces, 15, 19, 164, 176, 192, 223
Alewife, 19, 104, 203, 207
Algae, 47, 135, 159, 160, 163, 171, 195
Amphibians, 153
Amphipoda, 241
Anaerobic conditions, 48
Aquaculture, 228
Aquatic invasive species, 72
Aquatic plants, 71
Archaea, 115
Arctic, 216, 228
Area of Concern, 76, 244
Assessments, 78, 86, 112, 139, 152, 175, 187, 242, 247
Atmosphere-lake interaction, 15, 63, 99, 128, 150, 161, 192, 206, 240
Atmospheric circulation, 8, 194, 206, 215
Atmospheric transport, 78
Bacteria, 83
Balanced growth, 186
Ballast, 4, 110, 207
Bay of Quinte, 76
Behavior, 85
Beneficial management practices, 205
Benthic community, 242
Benthic flora, 135, 232
Benthos, 10, 25, 33, 41, 49, 52, 72, 78, 112, 124, 136, 139, 162, 197, 200, 208, 231
Bering Sea, 97
Bioaccumulation, 59, 107, 158, 164
Biodiversity, 42, 45, 145
Bioenergetics, 6, 175
Biogeochemistry, 35, 89, 115, 148, 169, 170, 203, 223, 229, 233, 246
Bioindicators, 77, 92, 105, 187, 212, 236
Biological field stations, 22
Biological invasions, 3, 20, 82, 94, 137, 163, 178, 232
Biological Station, 71
Biomagnification, 27, 103
Biomarker, 237

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

Biomonitoring, 29, 45, 71, 72, 147, 225, 237
Biosolids, 42, 238
Biotransformation, 37, 151
Bloom's Taxonomy, 18
Bottled water, 233
Buoys, 83
Burrowing mayflies, 48, 101
Carbon, 63, 159
Carbon cycle, 7, 19, 28, 38, 150, 161, 168, 169, 203, 212, 223, 246
Carbon filtration, 73
Cell viability, 153
Cemetery, 21
Cercopagis pengoi, 158
Changes 1996-2008, 195
Chemical analysis, 26, 92, 168, 189, 209, 212
Chiral PCBs, 118
Cisco, 34
Cladophora, 47, 93, 169, 174, 185, 220, 245
Climate change, 5, 60, 67, 113, 115, 119, 128, 133, 138, 147, 164, 178, 202, 210, 224, 228, 233, 235
Climates, 8, 27, 98
Climatology, 144, 206
Coastal dunes, 224
Coastal ecosystems, 39, 40, 121, 168, 220, 229
Coastal processes, 3, 27, 29, 130, 139, 156, 166, 239
Coastal structure, 131
Coastal wetlands, 66, 76, 119, 160
Coasts, 23, 105
Collaborative, 123
Community, 147, 179
Competition, 109
Complexity, 204
Computer models, 20, 73, 83, 99, 170
Conservation, 44, 121, 136, 234
Consortium, 123
Consumption advisories, 14
Consumptive demand, 143
Consumptive Use, 139
Correlation, 92
COSEE, 91
Crustaceans, 51
Curriculum, 221
Cyanobacteria, 13, 99
Cyanophyta, 45, 98, 132, 136, 148, 189, 218, 227, 231, 232, 239
Dam removal, 31
Data acquisition, 130

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

Data storage and retrieval, 142, 216
Database, 177
Decision making, 7, 9, 62, 111, 119, 215
Density, 25
Deposition, 43, 68, 215
Detroit River, 44, 66, 77, 110, 113, 121, 149, 191, 244
Detroit River Canadian Cleanup, 244
Diatoms, 28, 43, 124
Diporeia, 11, 136, 162, 231
Disposition, 118
Dissolve organic matter, 169
Dissolved organic matter, 176, 177, 209
Dissolved solids, 31, 238
Distribution patterns, 109, 146, 158, 176, 203
Diversion, 38, 233
Dreissena, 2, 24, 48, 89, 101, 130, 136, 139, 169, 178, 198, 200, 225, 229, 231
Drinking water, 8, 74, 98, 139, 147, 224
Drought, 135
Dunes, 135
Dynamic Factor Analysis, 100
E. coli, 185
Eastern Upper Michigan, 135
Economic evaluation, 57, 131, 137
Economic impact, 20, 116, 137, 231
Ecosystem engineer, 242
Ecosystem forecasting, 122, 225
Ecosystem health, 1, 12, 67, 93, 101, 102, 114, 160, 179, 183, 201
Ecosystem modeling, 107, 156, 169, 173, 175, 208, 214, 234, 235, 243, 244
Ecosystem-based, 123
Ecosystems, 15, 30, 31, 34, 65, 73, 81, 87, 89, 100, 116, 121, 123, 125, 167, 172, 198, 216, 242
Education, 1, 2, 18, 19, 35, 40, 51, 57, 65, 66, 74, 81, 85, 90, 91, 114, 116, 117, 118, 132, 142, 157, 186, 197, 204, 210, 213, 216, 217, 221, 223, 236, 247
Effect on ecosystems, 25
Emerging contaminants, 177
Endocrine disruption, 26, 217
Energy reduction, 154
Environmental contaminants, 26, 55, 74, 90, 93, 97, 103, 109, 110, 121, 147, 151, 155, 190, 201, 219, 245
Environmental curriculum, 65
Environmental education, 6, 16, 22, 39, 51, 65, 134, 157, 186, 211, 217, 247
Environmental effects, 17, 52, 126, 171
Environmental ethics, 16
Environmental health, 12, 26, 68, 109, 114, 121, 152, 157, 196, 197, 207, 221
Environmental policy, 75, 120, 151, 199, 205, 234
Environmental science and studies, 65
Eutrophication, 9, 33, 36, 47, 57, 71, 159, 160, 162, 173, 183, 193, 226, 243

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

Evaluation, 65, 90
Exotic species, 3, 24, 37, 62, 79, 110, 131, 194
Experimental design, 21
Fall cooling pattern, 106
Fatty acids, 80, 207
Field stations, 124
First Nations, 106, 179
Fish, 7, 14, 22, 26, 39, 46, 52, 54, 55, 62, 66, 69, 73, 75, 87, 88, 92, 93, 95, 113, 119, 140, 160, 171, 179, 183, 184, 200, 201, 221, 229
Fish aging, 180
Fish behavior, 37, 54, 141, 187
Fish consumption advisories, 103
Fish diets, 68, 100, 127, 152, 153, 175, 242
Fish diseases, 23, 58, 79, 236
Fish health, 105
Fish management, 12, 48, 49, 80, 101, 105, 149
Fish populations, 44, 48, 75, 79, 100, 149, 190, 191, 210, 222
Fish tagging, 80, 142
Fish toxins, 59, 111, 112, 141, 155
Fisheries, 36, 53, 93, 107, 165, 207
Flux Model, 143
Food chains, 27, 48, 68, 100, 104, 107, 153, 199
Funding, 71
Genetics, 10, 24, 28, 55, 79, 179, 182, 200, 211
Geochemistry, 9
Geology, 213
Geomorphology, 224
Geophysical technique, 131
Geophysics, 213
Georgian Bay, 33, 147
Geostatistics, 244
GIS, 8, 42, 85, 101, 138, 140, 188, 202, 208, 227
Global warming, 218, 228
Glyphosate, 99, 214
GPR, 21
GPS, 232
Great Lakes, 177, 219
Great Lakes basin, 5, 7, 27, 42, 49, 64, 85, 98, 106, 114, 124, 137, 143, 185, 200, 210, 216, 224, 241
Great Lakes Water Quality Agreement, 145
Green Bay, 197
Groundwater, 8
Groundwater mapping, 9
Habitats, 1, 75, 140, 149, 184, 200, 242
Harmful algal blooms, 55, 60, 95, 108, 132, 144, 155, 180, 185, 189, 231
Harvest control rules, 48

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

Hemimysis anomala, 242
Herbicides, 156
Hexagenia, 101
Hexagenia spp, 237
Historical landcover, 184
Holocene, 82, 135, 218
Human dimensions, 151
Human health, 26, 42, 46, 98, 110, 141, 157, 196, 215, 221, 245
Hydroacoustics, 119
Hydrodynamic model, 4, 98, 99, 129, 150, 169, 179, 208, 239, 240
Hydrodynamics, 3, 56, 57, 115, 130, 173, 229, 238
Hydrogeomorphology, 8
Hydrologic budget, 133, 143, 152, 182, 224
Hydrologic cycle, 113, 138, 146, 202
Hypoxia, 6, 87, 124, 193
Hypoxia extent, 244
IADN, 164, 194
Ice, 8, 43, 86, 98, 102, 165, 228, 233
Ice-ocean modelling, 97
Emerging Issues, 195
Impacts, 207
Indicators, 64, 68, 120, 201, 227
Information sharing, 138
Information System, 244
Inherent Optical Properties, 167
Inquiry Based Learning, 118
Institute, 186
Internal waves, 132
International trade, 233
Invasion success, 161
Invasive species, 2, 4, 18, 25, 39, 48, 49, 51, 53, 55, 61, 62, 70, 71, 81, 89, 95, 102, 109, 135, 145, 151, 158, 161, 174, 203, 207, 211, 216, 217, 218, 231, 241, 242, 246
Islands, 42
Jobs, 221
Lacustrine research, 186
Lake Agassiz, 24
Lake Erie, 4, 6, 10, 13, 22, 27, 28, 30, 31, 32, 36, 38, 40, 43, 44, 50, 54, 55, 56, 75, 80, 85, 86, 94, 95, 96, 98, 101, 107, 108, 111, 117, 119, 125, 127, 156, 162, 164, 170, 187, 193, 196, 201, 211, 214, 220, 227, 236, 237, 244
Lake Huron, 21, 29, 31, 54, 69, 87, 100, 139, 142, 155, 170, 182, 218, 226, 230, 242
Lake Malawi, 101
Lake management, 38, 68, 87, 120, 125, 183
Lake Michigan, 3, 5, 11, 34, 38, 39, 58, 59, 71, 78, 81, 82, 88, 95, 116, 122, 130, 163, 181, 192, 198, 224, 225, 240, 243
Lake model, 132, 144

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

Lake Ontario, 31, 47, 50, 51, 52, 56, 92, 127, 129, 139, 156, 160, 164, 169, 173, 183, 193, 201, 207, 222, 231, 234, 240, 242, 245
Lake Simcoe, 25, 71, 72, 169
Lake St. Clair, 4, 33
Lake sturgeon, 149
Lake Superior, 7, 24, 29, 38, 55, 68, 75, 89, 105, 128, 132, 148, 161, 177, 190, 191, 199, 212, 246
Lake trout, 12, 106, 182, 191
Lake Victoria, 49, 125, 180
Lake whitefish, 48
Lake Winnipeg, 171
Land use change, 113
Land use change modeling, 184
Legislation, 75, 103, 114, 224
Life history studies, 149, 229
Light, 203
Macroinvertebrates, 162, 181, 196
Management, 2, 15, 30, 34, 47, 65, 70, 102, 122, 123, 147, 172, 173, 184, 212, 216, 220
Marshes, 127
Mass balance, 28
Mathematical models, 31, 185, 220
Measuring instruments, 159
Media, 6
Mentoring programs, 174
Mercury, 14, 43, 78, 112, 126, 166, 181, 192, 215, 243
MERIS, 148
Metabolism, 56, 93, 168
Metals, 41, 153
Methylmercury, 12, 87, 152, 166, 196
Microbiological studies, 32, 37, 83, 89, 115, 226
Microcosms, 53
Microcystis, 22, 30, 55, 60, 128, 215, 239
Microzooplankton, 222
Migrations, 19
Minorities, 174
Mitigation, 18
Model studies, 20, 43, 50, 67, 88, 98, 137, 138, 162, 184, 187, 205, 210, 222, 226, 234
Model testing, 88, 94, 132, 144, 183
Mollusks, 76
Monitoring, 1, 16, 19, 23, 33, 35, 52, 74, 76, 96, 129, 134, 156, 159, 173, 204, 212, 236, 246
Morphotype, 191
Museum, 181
Mussels, 25, 39, 61, 130, 230
Mysids, 21, 112
Mysis, 230
Mysis relicta, 153

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

Nanoparticles, 153
Nearshore, 1
Nearshore Waters, 195
Net basin supply, 43, 46
Niagara River, 90
Nutrient load, 87
Nutrients, 35, 45, 46, 47, 50, 52, 56, 58, 80, 93, 95, 104, 108, 132, 139, 148, 171, 174, 190, 209, 230, 235
Observing systems, 83, 124
Organic carbon, 168
Organic compounds, 158, 168, 185
Organisms in trade, 72
Organizations, 116
OSL, 135
Otolith, 165
Outreach, 1, 27, 51, 66, 71, 90, 107, 117, 132, 134, 142, 213, 223
Over-lake precipitation, 43
Oxidative stress, 237
Oxygen, 10, 17, 35, 125, 237
PAHs, 67, 91
Paleolimnology, 112, 119, 170
Particle/gas partitioning, 67
Passive Sampling, 176
PBDEs, 194, 216, 225
PCBs, 14, 32, 37, 54, 91, 97, 118, 122, 141, 143, 155, 176, 188, 189, 196, 245
Pedagogy, 186
Pelagic fish, 230
Percids, 36, 63, 94, 214
Perfluorinated acids, 45
Perfluorooctane sulfonate, 164
Permits, 143
Pesticides, 15, 77, 91, 158, 189
Pharmaceuticals, 27
Phosphonates, 99
Phosphorus, 9, 25, 31, 80, 136, 156, 198, 214, 219
Photolysis, 177
Photosynthesis, 17, 19, 30, 59, 61, 84
Physical forcing, 17
Phytoplankton, 58, 59, 84, 148, 155, 173, 175, 222, 237
Picoplankton, 115
Plankton, 191, 199
Planning, 18, 125, 178, 186
Policy making, 3, 4, 44, 67, 103, 111, 120, 166, 173, 224
Political aspects, 21, 67
Pollutants, 53, 163
Pollution load, 9, 50, 104, 111, 137, 192

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

Pollution prevention, 27
Polycyclic musks, 188
Polymers, 74
Ponto-Caspian basin, 241
Population restoration, 182
Populations, 117
PPCPs, 238
Predation, 48, 51, 106
Princeton ocean model, 163
Productivity, 11, 47, 56, 79, 212
Professional certification, 157
Program accreditation, 157
PSCF, 32
Public education, 1, 6, 21, 103, 133, 136, 151, 197, 210
Public participation, 118, 172, 246
R/V Lake Guardian, 91
Radar, 43
Rainbow smelt, 6
Recruitment, 34, 88, 122, 190
Refugia, 87
Regional analysis, 38, 64, 75, 146, 202
Regional service collaboration, 154
Remediation, 77, 120, 140, 147, 159, 172
Remote sensing, 4, 25, 86, 102, 128, 129, 144, 148, 165, 167, 176, 195, 202, 213, 220, 227, 237, 239, 245
Research, 197
Reservoirs, 23, 62, 243
Respiration, 17
Restoration, 71, 167
Risk assessment, 22, 53, 59, 86, 238
Risks, 82, 114, 145
Rotifers, 69
Round goby, 37, 85, 107, 110, 141, 211
Saginaw Bay, 226
Salmon, 31, 104, 122, 142
Sand dunes, 5
Satellite technology, 13, 102, 129, 144, 165
Scientists, 186
Sediment control, 5
Sediment load, 87, 104
Sediment quality, 189, 208
Sediment resuspension, 203, 238
Sediment transport, 32, 86, 131, 139
Sediments, 14, 24, 41, 78, 80, 82, 125, 126, 151, 240
Seiche, 38
Seismic stratigraphy, 119

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

Seston, 80
Shipwrecks, 2, 136
Shore protection, 166
Signal processing, 205
Site selection, 94
Smelt, 203
Soft bottom, 242
Soil organic matter matter loss, 209
Spatial analysis, 42, 109, 156, 178, 199, 240
Spatial distribution, 2, 49, 63, 101, 113, 126, 194
Spawning bed, 149
Spawning site, 12
Species composition, 200
Species diversity, 136
SPMDs, 217
Sport Fish Consumption, 219
Spread, 109
St. Clair River, 4, 69, 179, 182
St. Lawrence River, 149, 166
St. Marys River, 62, 147
Stable isotope analysis, 181
Stable isotopes, 80, 105
Standards, 213
Steelhead, 31
STEM careers, 174
Stocks, 117
Strategic Great Lakes Fishery Management Plan, 145
Stressors, 156
Student research, 21
Submerged plants, 33
Surficial geology, 8
Sustainable Water Resources Agreement/Compact, 145
Swimming performance, 194
Technology, 66
Temperature, 203
Thermal Bar, 245
Thermal plume, 200
Time Series, 204
Toxic substances, 22, 68, 69, 164, 171, 192, 225
Tributaries, 75, 77, 127, 198, 214
Tributary runoff, 46
Trophic level, 11, 50, 100, 114
Trout, 45
Turbidity, 140, 212
Turbulence, 176
Ultraviolet radiation, 84

Abstracts of the 52nd Annual Conference on Great Lakes Research, May 18-22, Toledo, OH

Uncertainty, 46, 48
Unionids, 38, 76, 146, 200
Urban areas, 141, 143, 146, 172, 176, 188
Urban forest, 94
Urban watersheds, 16, 126, 147, 167, 219
Urbanization, 153, 173, 179, 188
Validation, 20
Vegetation, 135, 209, 232
VHS, 207, 228
Virus, 83
Vitamin B, 93
Walleye, 10, 80, 165
Wastewater, 73
Water, 73
Water availability, 227
Water balance, 20
Water level, 5, 29, 105, 152, 232
Water level fluctuations, 205, 218, 238
Water management, 114
Water quality, 1, 4, 10, 16, 18, 19, 23, 35, 57, 77, 90, 96, 107, 114, 126, 129, 134, 164, 202, 204, 217, 223, 226, 243, 244
Water use, 143
Water utilities, 154
Watersheds, 15, 30, 34, 44, 65, 67, 93, 111, 123, 125, 133, 138, 143, 146, 172, 179, 186, 188, 199, 211, 212, 216, 222, 234, 235, 236
Waves, 63, 132, 239
Western Basin, 80
Western Lake Erie, 200
Western Lake Erie Basin, 238
Wetlands, 53, 70, 71, 119, 153, 190, 209, 219
White perch, 180
Whitefish, 105
Wild rice, 127
Yellow perch, 6, 17, 28, 36, 58, 117, 140, 170, 187, 200, 208
Zebra mussels, 63, 72, 88, 109, 131, 161, 163, 178, 242
Zoobenthos, 242
Zooplankton, 11, 19, 29, 69, 80, 92, 112, 175, 181, 222

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