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ABSTRACT BOOK

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ADAMS, N.S., HOLBROOK, C.M., and HATTON, T.W., USGS Western Fisheries Research Center, 5501A Cook-Underwood Road, Cook, WA, 98605. **From Fine-Scale Fish Behavior to System-Wide Survival: Acoustic Telemetry Studies in Large Regulated Rivers.**

Advances in acoustic telemetry technology have allowed fishery researchers and managers to gather data that were previously unattainable using other methods. In addition to characterizing movements over large scales (e.g., passage routes and survival of fish during migration) acoustic telemetry can provide two- and three-dimensional fish location data at small scales. The ability to obtain fine-scale fish position data has greatly expanded our knowledge of fish behavior in complex environments. Our objective is to demonstrate how this technology has advanced our knowledge of fish behavior in a variety of environments and aided in the development of management strategies designed to improve survival of juvenile fish in heavily managed rivers. We will review studies that evaluate fish passage, behavior, and survival of juvenile fish in the Snake and Columbia rivers as well as in the Sacramento-San Joaquin River Delta. In the last ten years, studies have evolved from behavioral analyses in the forebays of large dams to integrated behavior and survival studies that encompass river systems. We will discuss the challenges we have encountered and the benefits associated with the evolution of the application of this technology. *Keywords: Acoustics, Fish populations, Fish behavior.*

AGHSAEE, P.[1], BOEGMAN, L.[1], and LAMB, K.G.[2], [1]Department of Civil Engineering, Queen's university, Kingston, ON, K7L 3N6; [2]Department of Applied Mathematics, University of Waterloo, Waterloo, ON, N2L 3G1. **Instability mechanisms and reflection of internal solitary waves shoaling upon coastal boundaries of lakes and oceans.**

The instability and breaking of fully nonlinear internal solitary waves shoaling upon a uniformly sloping boundary was investigated using high resolution two-dimensional numerical simulations. The simulations were performed for a wide range of boundary and wave slopes ($0.01 < S < 0.3$). Over steep slopes ($S > 0.1$), three distinct breaking processes were observed; surging, plunging and collapsing breakers which are associated with reflection, convective instability and boundary layer separation, respectively. Over mild slopes $S < 0.05$ nonlinearity varies gradually and fission results from dispersion. The dynamics of each breaker type were investigated and the predominance of a particular mechanism was associated with each breaker type. The breaking location was modeled as a function of wave amplitude (a), characteristic wave length (Lw) and the isopycnal length along the slope (Li). The breaker type was characterized in wave slope (a/Lw) versus S space and the reflection coefficient (R) was modelled as a function of the internal Iribarren number. High Reynolds numbers ($Re > 10^4$) were found to trigger a global instability, which modifies the breaking process, relative to the lower Re case, but not necessarily the breaking location and results in an increase in the reflection coefficient by approximately 10%. *Keywords: Coastal processes, Waves.*

AHMED, S.I., RUDRA, R.P., HUE, R., DICKINSON, W.T., and GHARABAGHI, D., SWchool of Engineering, University of Guelph, Guelph, ON, N1G2W1, Canada. **The Possible Impact of Changing Climate Characteristics on Soil and Water Resources in the Ontario Great Lakes Basin.**

The objective of the study was to evaluate the effect of climate change on soil erosion, and water quality and quantity in the Ontario Great Lakes Basin. The approach followed includes the development of future precipitation and temperature scenario using CGCM, downscaling the generated data, calibration and validation of watershed scale model, Soil and Water Assessment Tool (SWAT), and a field scale model, Erosion Productivity Impact Calculator (EPIC), using historical data, and simulations of future scenarios using SWAT and EPIC for soil and water quality. The results of the modeling study using SWAT with future weather predictions showed more evapotranspiration and thus the total water yield may decrease significantly. Also, the future stream flow may have longer low flow periods which may result in severe annual water deficiency by 2030 in streamflow. It could also result in a decrease in stream sediment transport capacity. The evaluation of changing climate impact on soil and water quality at field scale using EPIC model is expected to shed light on soil and water quality at field scale. *Keywords: Water quality, Water Buget, Watersheds.*

AHRENSTORFF, T.D. and HRABIK, T.R., Department of Biology, University of Minnesota - Duluth, Duluth, MN, 55812.
Seasonally Dynamic Diel Vertical Migrations of the Opossum Shrimp *Mysis relicta*, Coregonids *Coregonus* spp., and Siscowet Lake Trout *Salvelinus namaycush* in the Pelagia of Western Lake Superior.

Diel vertical migrations of organisms are often associated with changing light levels, while the underlying mechanisms are generally attributed to optimizing foraging efficiency or growth rates, while avoiding predation risk. From 2005–2008, we used an optical plankton counter, hydroacoustics, and midwater and bottom trawls to assess seasonal changes in vertical migration patterns of the Lake Superior pelagic food web containing opossum shrimp *Mysis relicta*, kiyi *Coregonus kiyi*, cisco *C. artedi*, and siscowet lake trout *Salvelinus namaycush*. In addition, we applied foraging, growth, and predation risk models to provide insight into why observed migration patterns vary between species and seasons. Our results suggest that mysis, kiyi, and siscowet lake trout migrate concurrently during each season, but to a lesser extent in spring compared to summer and fall. In comparison, cisco migrate less extensively regardless of season. Our modeling approach suggests that foraging potential and predation risk influences the movement patterns of mysis, kiyi, and cisco, while foraging potential alone describes the vertical movements of siscowet lake trout. Cisco movement patterns also relate to highest growth potential, while for the other species higher growth rates could be achieved at various other depths. *Keywords: Hydroacoustics, Fish behavior, Lake Superior.*

ALADIN, N. and PLOTNIKOV, I., Universitetskaya nab. 1, St.-Petersburg, 199034, Russian Federation.
Changing of the biodiversity (paleo and recent) in the Caspian Sea.

The Caspian Sea is the world's largest lake and one of the most ancient lakes. It is the remnant of Paratethys. The whole Caspian area can be divided by three parts differing in hydrology. An important feature great diversity of physico-chemical conditions. Salinity differs in different parts of the lake. Recent biodiversity reflects the story of Palaeo-Caspian transgressions and regressions followed by freshening and salinization. Four main components

form the present biodiversity of the Caspian Sea: Caspian, Arctic, Atlantic and Mediterranean, fresh-water. Biodiversity began increase after building the Volga-Don canal due to invasions with boat ballast water or in biofouling. At the end of the 20th century ctenophore *Mnemiopsis leidyi* has invaded the Caspian Sea. In 2000 it was numerous in the Middle and Southern and appeared in the Northern Caspian. Due to recent *Mnemiopsis* invasion we have a great risk for Caspian Sea ecosystem. This organism could harvest nearly all plankton and due to this all ecosystem could collapse. In waters of Azerbaijan nearly all endemic Onychopoda already disappeared because of predation. Introduction of *Beroe ovata* to prevent catastrophe is discussed. *Keywords: Invasive species, Caspian Sea, Biodiversity.*

ALI, K.A., WITTER, D.L., and ORTIZ, J.D., 221 McGilvrey Hall, Department of Geology, Kent State University, Kent, OH, 44242.
An improved method for optical-feature extraction from multi-spectral data.

Remote sensing has become very promising in providing temporal and spatial information regarding biogeodynamics in large, and open freshwater bodies. However, in optically complex environments, such as in the Western Basin of Lake Erie, the water contains multiple constituents including phytoplankton, sediment, and organic carbon. Identifying and analyzing in-water constituents in such waters is crucial for understanding and assessing the biogeochemical process of interest, i.e., phytoplankton and sediment dynamics. Determining the in-water constituents from satellite observations is complicated when working with mixed spectral signatures. This study focuses on improving the quantification of phytoplankton and sediment concentrations, independently, by applying signal decomposition to the reflectance data using spectra transformation. This study indicates that applying spectral transformation using wavelet analysis, results in increased accuracy as compared to using other feature extraction methods such as the principle component analysis of untransformed spectra and conventional spectral indices. The superior results of the wavelet technique in discriminating between the various water constituents can be attributed to the frequency content retrieved by the wavelet technique combined with the localization property of wavelets. *Keywords: Remote sensing, Lake Erie, Water quality.*

ALLAN, B.V.[1], POND, B.R.[2], GEE, K.R.[1], HERNANDEZ, P.A.[3], and MEYER, S.A.[1], [1]Ministry of Natural Resources, Midhurst District Office, 2284 Nursery Road, Midhurst, ON, LOL 1XO; [2]Ministry of Natural Resources, Wildlife Research and Development Section, Peterborough, ON, K9J 7B8; [3]Ministry of Natural Resources, Aurora District Office, 50 Bloomington Road, Aurora, ON, L4G 0L8.
Monitoring the Terrestrial Natural Heritage and Hydrologic Features in the Lake Simcoe Watershed.

The Lake Simcoe Protection Plan (LSPP) commits the Ministry of Natural Resources (MNR), and its partners the Ministry of the Environment (MOE) and the Lake Simcoe Region Conservation Authority (LSRCA) to develop and implement a monitoring program that measures the state of the natural heritage and hydrologic features in the terrestrial landscape of the Lake Simcoe watershed. This task was broken down into two phases, a program development phase and an implementation phase. A framework was drafted that uses a Pressure-State-

Response model to develop and organize a suite of state indicators. The framework calls on the creation of a foundation report to provide the background materials and options for a watershed-wide monitoring plan. The foundation report is a technical report that outlines the information for a theme that can be used to identify appropriate indicators for monitoring. Themes in the foundation report include natural cover, valleyland, riparian habitat and ecological health. Once the development phase is complete, an implementation report will guide phase 2 of the monitoring program. Through the LSPP, outputs of this monitoring program will help inform government policy and decision making. *Keywords: Ecosystem health, Monitoring, Lake Simcoe.*

ALLAN, B.V.[1], NORMAN, A.J.[3], MCINTYRE, C.A.[1], GEE, K.R.[1], HERNANDEZ, P.A.[2], SEYSMITH, C.E.[2], and OSMOK, J.P.[1], [1]Ministry of Natural Resources, Midhurst District Office, 2284 Nursery Road, Midhurst, ON, LOL 1XO; [2]Ministry of Natural Resources, Aurora District Office, 50 Bloomington Road West, Aurora, ON, L4G 3G8; [3]Minsitry of Natural Resources, Southern Science and Information Section, 659 Exeter Road, London, ON, N6E 1L3. **Wetland and Riparian Habitat Restoration in the Lake Simcoe Watershed.**

The Lake Simcoe Protection Plan sets a number of targets and indicators to minimize future impacts on the lake and to protect and restore natural heritage features. Some of the natural heritage targets will be achieved through a strategy to delineate priority areas for wetland and riparian restoration. A thorough analysis of potential wetland and riparian restoration sites in the watershed was conducted and priority sites were established through a series of ecological, social and historical analyses. Initial scoping of the 18 Lake Simcoe subwatersheds was undertaken to identify 3 candidate subwatersheds. White's Creek, Innisfil Creeks and Maskinonge River were identified. From preliminary scoping within those three sub-watersheds approximately 75 potential sites were found. Data were collected on over 25 attributes for the 3 subwatersheds in three main categories: biological, water quality/quantity and social/political. This analysis will provide a foundation for long-term wetland and riparian rehabilitation efforts by numerous partners and will help to inform future land management and planning decisions. *Keywords: Wetlands, Tributaries, Lake Simcoe.*

ALLAN, J.D., HAN, H., and BOSCH, N.S., School of Natural Resources and Environment, University of Michigan, Ann Arbor, MI, 48109. **Spatial and Temporal Variation in Phosphorus Budgets for 24 Lake Erie and Lake Michigan Watersheds.**

We estimated net anthropogenic phosphorus inputs (NAPI) to 18 Lake Michigan (LM) and 6 Lake Erie (LE) watersheds for 1974, 1978, 1982, 1987, and 1992. NAPI quantifies all anthropogenic inputs of P (fertilizer use, atmospheric deposition, and detergents) as well as trade of P in food and feed, which can be a net input or output. Fertilizer was the dominant input overall, varying by three orders of magnitude among the 24 watersheds, but detergent was the largest input in the most urbanized watershed. NAPI increased in relation to area of disturbed land ($R^2=0.90$) and decreased with forested and wetland area ($R^2=0.90$). Export of P by rivers varied with NAPI, especially for the 18 watersheds of LM ($R^2=0.93$), whereas the relationship was more variable among the six LE watersheds ($R^2=0.59$). On average, rivers of the LE

watersheds exported about 10% of NAPI, whereas LM watersheds exported 5% of estimated NAPI. A comparison of our results with others as well as nitrogen (N) budgets suggests that fractional export of P may vary regionally, as has been reported for N, and the proportion of P inputs exported by rivers appears lower than comparable findings with N. *Keywords: Watersheds, Nutrients, Phosphorus.*

ALLEN, J.[1] and AUSTIN, J.A.[2], [1]Department of Geology, University of Minnesota, Duluth, Duluth, MN, 55812, USA; [2]Large Lakes Observatory, University of Minnesota, Duluth, Duluth, MN, 55812, USA.
The sensitivity of lake thermal structure to changes in meteorological focring.

The formation of thermal structure in large lakes is dependent on complex interactions between the surface and the atmosphere. In order to gain an understanding of the sensitivity of the lake to various atmospheric inputs as well as seasonal variables we use numerical modeling techniques as well as observed data. We use a one dimensional model, forced with realistic meteorological measurements, to determine sensitivity of summer lake thermal structure including surface temperature, heat content, and mixed layer depth. Forcing parameters: air temperature, wind speed, and previous winter ice cover, are varied here to replicate long term trends over the past few decades. Average summer surface temperature increased with increased air temperatures, decreased ice cover, and decreased wind speeds. Heat content responded most significantly to ice cover variations, with changes in initial water temperatures (a proxy for winter ice cover) maintaining throughout the summer season. Mixed layer depth responded to wind speed, with increases in wind speed leading to increased depth of the surface mixed layer. *Keywords: Hydrodynamic model, Climate change.*

ANDERSON, E.J.[1] and SCHWAB, D.J.[2], [1]University of Michigan - CILER, 4840 S. State Rd, Ann Arbor, MI, 48108; [2]NOAA - Great Lakes Environmental Research Lab, 4840 S. State Rd., Ann Arbor, MI, 48108.
Hydrodynamic Modeling and Contaminant Tracking in the St. Clair River for Public Water Safety and Spill Response.

The Huron-Erie Corridor (HEC) is home to commercial shipping and industrial plants in the St. Clair River and serves as source water for numerous surrounding communities. As such, the potential for contaminant spills in the river to reach public water intakes along the corridor is of great concern. In order to assess possible contaminant trajectories and provide information for public water management and spill response, a hydrodynamic model of the HEC has been developed for real-time predictions of currents and water levels. In August 2009, dye experiments were carried out to mimic a spill in the St. Clair River. Observations of travel time and plume dispersion were compared to computer simulations of dye and particle releases using the Huron-Erie Connecting Waterways Forecasting System (HECWFS). Overall, the path and concentrations of a potential release may be highly dependent on the location of the spill. A series of spill scenarios were carried out to quantify a range of potential releases in the river. These simulations have been incorporated into a library of spill scenario forecasts that can be used at the time of a spill to estimate travel time, peak concentration, and exposure time of the

spill at numerous water treatment plants along the corridor as well as for spill response. *Keywords: St. Clair River, Drinking water, Hydrodynamics.*

APFELBAUM, S.I.[1], DEKKER, T.J.[2], and VANVALKENBURGH, M.[3], [1]Applied Ecological Services, Brodhead, WI, 53520; [2]LimnoTech, Ann Arbor, MI; [3]Michale Van Valkenburgh and Associates, New York, NY. **An Ecologist's Perspective on the Don River Naturalization: Toronto, Canada.**

As urban rivers in the Great Lakes have been altered by the effects of shoreline development and watershed urbanization, many problems, including damages from flooding, impaired water quality, and impacts to biological communities have resulted. Like most urban rivers in the Great Lakes, the Don River in Toronto is impacted by a complex combination of factors that have not been successfully addressed historically. Solutions have typically focused only on a single aspect of the problem, rather than the complex whole. The Don River naturalization project design attempts to understand the challenges of restoring river function in a constrained urban setting, where urban infrastructure and land use contribute to extreme flooding, high sediment loads, compromised water quality, and limited biodiversity. Instead of the single problem, single solution, we have optimized a suite of solutions that first are driven by the site constraints and limitations, secondly by solving mandatory problems such as flooding, and then by conceptualizing a ririver restoration. The result is what may be the first-ever reconstruction and restoration of a new Great Lakes river mouth, with an associated park system that would accommodate floodwaters, create a restored river mouth ecology, and provide habitat for species diversification. *Keywords: Habitats, Ecosystems, Lake Ontario.*

ARHONDITSIS, G.B.[1], CHENG, V.[1], KUMARAPPAH, A.[1], BRETT, M.T.[2], and BHAVSAR, S.[3], [1]University of Toronto, Toronto, ON; [2]University of Washington, Seattle, WA; [3]Ontario Ministry of the Environment, Toronto, ON. **Should We Trust the Phosphorus Loading Models? A Bayesian Hierarchical Reassessment.**

We revisit the phosphorus retention and nutrient loading models in limnology using a Bayesian hierarchical framework. This methodological tool relaxes a basic assumption of regression models fitted to data sets consisting of observations from multiple systems, i.e., the systems are assumed to be identical in behaviour, and therefore the models have a single common set of parameters for all systems. Under the hierarchical structure, the models are dissected into levels (hierarchies) that explicitly account for the role of significant sources of variability (e.g., morphometry, mixing regime, geographical location, land use patterns, trophic status), thereby allowing for intersystem parameter differences. Thus, the proposed approach is a compromise between site-specific (where limited local data is a problem) and globally-common (where heterogeneous systems in wide geographical areas are assumed to be identical) parameter estimates. Finally, our analysis demonstrates how the Bayesian hierarchical framework can be used for assessing the exceedance frequency and confidence of compliance of water quality standards. We conclude that the proposed methodological framework will be very useful in the policy-making process and can optimize environmental management actions in space and time.

Keywords: Water quality criteria, Eutrophication, Bayesian inference, Phosphorus, Risk assessment, Model testing.

ARMENIO, P.M. and MAYER, C.M., Department of Environmental Sciences and the Lake Erie Center, The University of Toledo, Toledo, OH, 43616. **Nutrient contributions from *Dreissena* to the benthic cyanobacterium *Lyngbya wollei*.**

The cyanobacterium *Lyngbya wollei* has recently become abundant on the bottom of Lake Erie; it becomes a nuisance because it floats to the surface and can form meter-deep masses along the shoreline. *Dreissena* spp. (zebra and quagga mussels), clear the water column and increase light to the benthos and may also contribute a limiting nutrient to the benthic algae, facilitating blooms. Manipulative experiments showed that *Lyngbya* had higher chlorophyll *a* and phycocyanin in tanks with live dreissenid mussels than tanks without live mussels. *Lyngbya* also had a higher concentration of carbon, nitrogen, phosphorus, potassium, and sulfur in the tanks with live *Dreissena*. However, *Lyngbya* had a lower concentration of calcium in the tanks with live mussels. None of the tanks had a phosphorus deficiency, but did have a moderate nitrogen deficiency; although, *Lyngbya* from the live *Dreissena* tanks had less of a nitrogen deficiency, and was borderline no deficiency. These results suggest that *Dreissena* give nutrients to *Lyngbya* thereby making it photosynthetically healthier. Since *Dreissena* give these resources to the benthic algae, the mussels can therefore promote algal growth and productivity and aid in bloom formation. *Keywords: Invasive species, Productivity, Algae, Nutrients.*

ARNOLD, R.T., Drinking Water Source Protection, Grey Sauble Conservation Authority, Owen Sound, ON, N4K 5N6. **On certainty economics of integrated data management for Drinking Water Source Protection.**

The Clean Water Act was passed by the Province of Ontario in 2006, leading to the Drinking Water Source Protection (DWSP) Program. After the Terms of References were negotiated, this program produces a science-based assessment report and then develops policies to protect drinking water sources through a committee of local stakeholders. The program legally establishes modeling as tool for planning and zoning. Scientific uncertainties remain, related to data sources and the conceptualization of the area. Regular improvements of model results and thus zoning are anticipated – either as part of the 5-year update cycle, or in cases where scientific knowledge may be legally challenged, for example before the Ontario Municipal Board. How can the public agencies that oversee this process of regular updating minimize the costs of model- and data management over such time horizon, while ensuring that the certainty of information is actually improved? The certainty of information can be regarded as a good that a public agency generates. Certainty improvements should be optimized economically to minimize the costs for DWSP. This article discusses options for model and data management. A process is outlined that guarantees past knowledge is not lost in update cycles and ensures that information is generated consistently and transparently. *Keywords: Economic evaluation, Model testing, Drinking water.*

ASHMORE, P.[1], BEST, J.[2], CZUBA, J.[2], DENNY, J.[4], FOSTER, D.[4], OBERG, K.[3], GARCIA, M.[2], LIU, X.[2], PARKER, G.[2], and PARSONS, D.[5], [1]University of Western Ontario, London; [2]University of Illinois, Urbana-Chapaign; [3]U.S. Geological Survey, Urbana-Champaign; [4]U.S. Geological Survey, Woods Hole; [5]University of Leeds, Leeds, UK. **Morphology, sedimentology and dynamics of the upper St. Clair River.**

Recent video and acoustic surveys of the upper St. Clair River, as part of the International Upper Great Lakes Study, have revealed new information about the geology, morphology and substrate of this unusual, non-alluvial, river. The upper 1-2 km of the river is underlain by a considerable thickness of fluvio-glacial gravel, which thins downstream, with clay till beneath. The river bed is dominated by this coarse gravel-cobble material but, where this deposit thins-out, glacial till is exposed in some areas. Bed material grain size appears to be in equilibrium with prevailing flows, transport of the gravel is minimal and sediment load is restricted to low intensity background sand flux and suspension of fines in the lake. Features of the bed include local scour around obstacle (e.g. ship wrecks), deep pools in the bends, linear grooves and ridges in till, and some areas of transverse bed waves in gravel and sand. Hydraulic and grain size analysis indicates that much of the bed material is not erodible under present flow conditions, leading to the hypothesis that the bed waves and ridge-groove features are related to propeller wash and other ship effects that disturb the bed. *Keywords: St. Clair River, Acoustics, Sediment transport.*

ASPINALL, J.D.[1], THUSS, E.P.[2], and SWEENEY, S.J.[1], [1]1 Stone Rd W, Guelph, ON, N1G4Y2; [2]200 University Avenue West, Waterloo, ON, N2L3G1. **Addressing soil landscape database challenges: an application of predictive soil mapping in the Lake Simcoe watershed.**

The digital soil landscape database information for the Lake Simcoe watershed in southern Ontario requires significant improvements to facilitate meaningful multi-scale water quality modelling. This paper describes the approaches taken to address this issue. Legacy soil landscape information for this watershed included a digital elevation model (DEM) built from elevation contours in 2002 and a series of digitized county-level soil survey maps (1950's originals at 1":1mile). A predictive soil mapping method was employed to maintain the essence of the original soil map unit (soil series) concepts but automate the shifting on their digital polygon boundary positions into appropriate landscape positions as represented on the detailed DEM framework. A Laplacian operation was performed on the DEM to characterize landform feature curvatures – concavities and convexities. The LandMapR toolkit of programs for processing DEM's and classifying soil landscapes was applied to extract terrain attributes. The SoLIM (Soil Land Inference Model) was then employed in setting up a sequence of rules to assign soil catenas to their proper landscape positions. The resulting seamless, digital soil map layer now positions the legacy soil map units in correct alignment with the landscape feature resolution of the DEM. *Keywords: Pollution sources, Digital soil mapping, GIS, Lake Simcoe.*

AUER, M.T.[1], BOWEN, G.[2], and HOWELL, E.T.[3], [1]Department of Civil & Environmental Engineering, Michigan Technological University, Houghton, MI, 49931; [2]Toronto and Region Conservation, Downsview, ON, M3N 1S4; [3]Environmental Monitoring & Reporting Branch,

Ontario Ministry of the Environment, Etobicoke, ON, M4V 1P5.
Monitoring, Modeling & Management of Water Quality in the Lake Ontario Nearshore at Ajax, Ontario.

Water quality improvements achieved for the Lake Ontario offshore have not been universally realized in nearshore waters. Lost beneficial uses relate to proliferation of Cladophora, levels of fecal bacteria and poor clarity. Management of the system's 'land side' derives guidance from models supported by a comprehensive and sophisticated suite of monitoring and remote sensing capabilities. No comparable platform is widely available for the 'water side', i.e. to assess the response to 'land-side' management. Toronto and Region Conservation (TRCA), responsible for 60 km of Lake Ontario waterfront, presently manages watersheds including the Duffins/Carruthers Creek system located near Ajax, Ontario. Pollutant loads from this system have been reduced through a proactive program of education, land use management and land acquisition. Further progress would be facilitated by application of a tool quantifying the relative roles of lakewide, regional and local stressors in mediating water quality. Here, we describe a steady-state, 2D model applied for that purpose. The model uses loading estimates and field data from TRCA's monitoring program to compare the impact of local (stormwater inputs, the Duffins and Carruthers Creek discharges and a treatment plant point source), regional (longshore) and lakewide (offshore) stressors. *Keywords: Lake Ontario, Nearshore, Model studies, Monitoring.*

AUSTIN, J.A., Large Lakes Observatory, University of Minnesota, Duluth, Duluth, MN, 55812, USA.
Resolving a persistent offshore temperature maximum using an Autonomous Underwater Glider.

In November 2009, we deployed a Webb Research Autonomous Underwater Glider in western Lake Superior. It continuously occupied a 12-km long cross-shelf section of the Wisconsin shelf for 12 days, making 26 full surveys of the section. The shelf waters were cooling off steadily during this period. We observed a persistent offshore temperature maximum on the order of 0.5C above the coastal or offshore surface temperature. This appears to be due to the competing effects of more rapid cooling in shallow, onshore water, and the mixing of deep cold water into offshore surface waters. While this temperature maximum may not be of fundamental importance in and of itself, it represents a phenomenon that would be difficult to resolve through more familiar sampling schemes, such as shipboard CTD surveys or moored instrumentation. *Keywords: Lake Superior, Thermal structure, Atmosphere-lake interaction, Coastal processes.*

AVON, L., KENNEDY, I., and MALIS, G., Health Canada, Pest Management Regulatory Agency, Environmental Assessment Directorate, 2720 Riverside Dr., Ottawa, ON, K1A 0K9.
Estimation of Pesticide Concentrations in Surface Water and Groundwater for Human Health and Ecological Exposure.

Estimating concentrations of pesticides in water bodies is an integral part of the environmental risk assessment process conducted by Health Canada's Pest Management Regulatory Agency (PMRA). The PMRA has developed a methodology for estimating pesticide

concentrations in relationship to proposed and registered pesticide application practices across Canada. Computer simulations are used to estimate pesticides concentrations in surface water and groundwater. For surface water, PMRA uses the linked PRZM and EXAMS models. For groundwater, PMRA uses the LEACHM model. Concentrations in surface water and groundwater are estimated for a series of agricultural scenarios that are typical of the major crop-growing areas in Canada using regional meteorological data, characterisation of soils and crops, and chemistry and environmental fate data from the PMRA review process. For surface water, PMRA currently uses three scenarios, a small reservoir, prairie dugout and a small pond. Daily pesticide concentrations in surface water and groundwater are estimated for a multi-year period and summary statistics computed. These results are used to assess risks to human health and the environment in the context of registration decisions. *Keywords: Pesticides, Risk assessment methods, Assessments.*

AWAD, E., MAHON, C., BHAVSAR, S., and PETRO, S., Ontario Ministry of Environment, 125 Resources Road, Etobicoke, ON, M9P 3V6. **Contaminants in Sport Fish from the Toronto Waterfront.**

The Toronto area watershed was identified as an Area of Concern by the International Joint Commission in 1985 due to various impairments including restrictions on fish consumption. The Ontario Ministry of Environment has been collecting and analyzing fish from the Toronto waterfront since 1975 and this data has been used to assess this Beneficial Use Impairment. Currently, consumption restrictions exist for most species, but are most stringent for salmonids (i.e., salmon and trout) and other lipid-rich species. Restrictions are mainly caused by PCBs, with some species/sizes restricted due to elevated mercury and dioxins/furans. In July 2009, a comprehensive sport fish sampling program was conducted in the Toronto waterfront in collaboration with the Toronto and Region Conservation Authority. In total, 217 samples of 10 fish species were collected from 24 locations. These samples will result in over 8000 data points for various legacy and emerging-concern contaminants. This presentation will include the results of some of these chemical analyses as well as a comparison to previous data to evaluate contaminant trends. Updated sport fish consumption advisories, based on these new measurements, and a comparison to previous advisories will also be presented. *Keywords: Fish toxins, Urban watersheds, PCBs.*

AZIM, E.[1], KUMARAPPAH, A.[1], BHAVSAR, S.[2], and ARHONDITSIS, G.B.[1], [1]University of Toronto, Toronto, ON; [2]Ontario Ministry of the Environment, Toronto, ON. **Spatiotemporal Trends of Mercury in Lake Erie Fish Communities.**

Founded upon Bayesian inference techniques, we introduce a modeling framework to evaluate the spatio-temporal trends of total mercury (Hg) in several pelagic and benthic fish species in Lake Erie. First, we use the exponential and mixed-order decay models to assess the declining rates in three intensively studied species, i.e., walleye, yellow perch, and smallmouth bass, over the last 35 years. Because the two models postulate monotonic decrease of the Hg levels, we included first- or second-order random error terms in our statistical formulations to accommodate any non-monotonic patterns in the time series data. Our analysis indeed reveals an

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increasing trend in the Hg concentrations, which becomes particularly evident after the mid-90s. Then, we introduce a Bayesian hierarchical model structure to infer about the Hg trends in less intensively studied species (coho salmon, lake trout, white bass, rainbow trout, northern pike, and freshwater drum) by "borrowing strength" from the three well-studied species. Finally, we argue that the recent increase in fish Hg may be explained by the Hogan et al. (2007) conceptual model that invokes the role of invasive species (dreissenid mussels and round goby) in inducing structural shifts of the Lake Erie food web. *Keywords: Mathematical models, Environmental contaminants, Bayesian inference, Fish management, Lake Erie, Mercury.*

BADE, D.L., CLEVINGER, C.C., and HEATH, R.T., Kent State University, Box 5190, Kent, OH, 44242. **A Review of Nitrification and Its Role in Lake Erie.**

Nitrification is the oxidation of ammonium to nitrite or nitrate. Nitrification is an autotrophic process, yet unlike photosynthesis, it consumes oxygen. This process, carried out by prokaryotes, has been studied extensively in soil and marine environments. However, relatively little work has been done to quantify nitrification and its limitations in freshwater habitats. Here we provide a review of knowledge about limitations to nitrification from other environments, and summarize rates of nitrification. These rates and limitations are then considered in the context of Lake Erie and compared with our own measurements. Limitations suggested from the literature include ammonium and oxygen availability, prokaryote density, and light. In Lake Erie we were not able to show limitation related to ammonium concentration. Rates from the literature are variable, but within a magnitude that could have significant influence on the biogeochemistry of Lake Erie. For example, literature results from a eutrophic lake found rates that ranged from .03 - .62 μg N L^{-1} hr^{-1} . In Lake Erie this would account for 4-80% of the average biological oxygen demand in the Central Basin. Our own measurements confirm that rates of this magnitude do occur in the lake. *Keywords: Biogeochemistry, Nitrogen, Lake Erie.*

BADIOU, P.[1], PAGE, B.[1], BOYCHUK, L.[2], GABOR, S.[1], YANG, W.[3], and WANG, X.[4], [1]1. IWWR, Ducks Unlimited Canada, Stonewall, MB, R0C 2Z0; [2]Ducks Unlimited Canada, Regina, SK; [3]Department of Geography, University of Guelph, Guelph, ON; [4]Department of Engineering and Physics, Tarleton State University, Stephenville, TX. **Discharge and water quality in a highly drained landscape: Impacts of Wetland Loss in South-Western Manitoba and implications for Lake Winnipeg.**

Ducks Unlimited Canada has been studying the Broughton's Creek watershed for the last several years in order to determine the impacts of wetland drainage on water quality and downstream flows. Our results indicate that discharge in this prairie watershed occurs over a relatively short period of time in the spring when melt water is high in dissolved nutrients. Based on these findings protecting and restoring wetlands in the Canadian prairies is a cost effective way to help reduce nutrient loading to Lake Winnipeg. Our results also suggest that current water quality monitoring strategies in the Canadian Prairies should be revisited in order to accurately determine nutrient loading to rivers and lakes. *Keywords: Wetlands, Watersheds, Nutrients.*

BAI, X.[1] and <u>WANG, J.</u>[2], [1]CILER, University of Michigan, 4840 South State Rd., Ann Arbor, MI, 48108; [2]NOAA/Great Lakes Environmental Research Lab., 4840 South State Rd., Ann Arbor, MI, 48108.
Simulations of water circulation and temperature in the Great Lakes with FVCOM.

An unstructured Finite Volume Coastal Ocean Model (FVCOM) was applied to all five Great Lakes to simultaneously simulate water circulation and temperature conditions over a seasonal cycle. Lakes Michigan, Huron, St. Clair and Erie were connected, while Lakes Superior and Ontario were kept disconnected with others due to the nature of human management. Daily means of winds, air temperature, specific humidity and cloudiness from the North American Regional Reanalysis (NARR) dataset were used to force the model. Seasonal cycle of circulation and water temperature of the Great Lakes were obtained. Response of each lake to atmospheric forcing was studied. Using the simulations, a comparative investigation of water circulation and temperature was conducted to study the horizontal and vertical structures of temperature and circulation under the same synoptic atmospheric forcing. Lake-wide measurements were collected to validate the model. This model will serve a backbone model for future coupling to a lake ice model, and ecosystems models. *Keywords: Great Lakes basin, Water temperature, Hydrodynamic model, Water currents.*

<u>BAILEY, S.A.</u>[1], DENEAU, M.G.[1], JEAN, L.[2], WILEY, C.J.[3], LEUNG, B.[4], and MACISAAC, H.J.[5], [1]Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, 867 Lakeshore Road, Box 5050, Burlington, ON, L7R 4A6; [2]Transport Canada, 901 Cap-Diamant, Québec City, QC, G1K 4K1; [3]Fisheries and Oceans Canada/Transport Canada Marine Safety, 100 Front Street South, Sarnia, ON, N7T 2M4; [4]Department of Biology & the McGill School of Environment, McGill University, 1205 Docteur Penfield, Montréal, QC, H3A 1B1; [5]Great Lakes Institute for Environmental Research, University of Windsor, 401 Sunset Ave, Windsor, ON, N9B 3P4.
Have Ballast Water Policies for the Great Lakes Reduced the Risk of Ship-mediated Aquatic Invasions?

Measuring the impact of environmental policy is particularly challenging for regulations targeting prevention of aquatic nonindigenous species (ANS) introductions due to a dearth of comparative data and the absence of direct indicators of successful management. Yet, understanding policy efficacy is essential for productive management decisions, especially given inadequate funding. International ballast water discharge standards have been proposed to minimize spread of ANS. In order to evaluate the efficacy of the proposed standards, we must first have a comprehensive understanding of current risks. Here, we explore the efficacy of ballast water management policies in the Great Lakes using four lines of evidence. First, we extend previous analyses of rates of discovery of ANS to determine if a decline is evident. We then examine the theoretical efficacy of ballast exchange by modeling expected loss ratios based on empirical data. Third, we examine vessel compliance statistics and, finally, compare biotic composition of ballast water collected before and after the introduction of regulations. Our results indicate that ballast water exchange and tank flushing provide robust protection for the Great Lakes, but that the proposed international standards would further reduce the number of individuals transported in ballast tanks. *Keywords: Ballast, Biological invasions, Zooplankton.*

BAKELAAR, C., DOOLITTLE, A., and DOKA, S., Fisheries & Oceans, 867 Lakeshore Rd, Burlington, ON, L7R 4A6. **Integrated Spatial Framework for Storage & Analyses of Fish Habitat Data in Hamilton Harbour, Lake Ontario.**

Hamilton Harbour (Lake Ontario) has been identified as a Great Lakes' Area of Concern (AOC) signifying that its ability to support aquatic life has been impaired. Contributing to science and restoration efforts in this degraded area reflects Fisheries & Oceans Canada's (DFO) commitment to ensuring healthy and productive ecosystems. In 2006, DFO's Great Lakes Laboratory for Fisheries and Aquatic Sciences (GLLFAS) began a number of projects to assess the current state of Hamilton Harbour. Together, they will assess progress toward Remedial Action Plan (RAP) targets for fish habitat and populations of phytoplankton, zooplankton, benthos and fishes, and evaluate the ability of the ecosystem to meet all of the RAP's targets. An integrated spatial framework approach has been used to assemble physical and modelled fish habitat data into a geographic information system (GIS). This approach synthesizes data from different projects, and is used as a guide in standardizing formats, data structures and data layers that are used in generating and mapping key habitat features (vegetation, substrate, depth), as well as supporting fish habitat, population and ecosystem modelling needs. Difficulties encountered will be discussed as well as rationale for the approach used. *Keywords: Ecosystem modeling, Spatial analysis, Fish habitat, GIS.*

BAKER, D.B., RICHARDS, R.P., and CRUMRINE, J.P., Heidelberg University, 310 E. Market Street, Tiffin, OH, 44883. **Causes of Increased Dissolved Reactive Phosphorus Loading to Lake Erie.**

After declining between 1975 and 2005, concentrations and loads of dissolved reactive phosphorus to Lake Erie from predominantly agricultural watersheds in Ohio have increased sharply during the past ten years. Suggested causes include increased soil phosphorus concentrations, focusing of phosphorus in the upper several centimeters of the soil (stratification), application of fertilizer and manure in the fall and winter, and application of fertilizer and manure to the soil surface without incorporation. The objectives of this presentation are to communicate results of recent research into the extent of soil phosphorus concentration increases and stratification in these watersheds, to evaluate the probable relative importance of the causes for increased phosphorus loading proposed above, and to suggest better management practices and explore why they are not already in place. *Keywords: Eutrophication, Phosphorus, Lake Erie.*

BALDWIN, B.S., 123 Johnson Hall, St. Lawrence University, Canton, NY, 13617. **Are Ecosystem Impacts of Exotics Pronounced Near Confluences of the St. Lawrence River and its Tributaries?**

Populations of exotic dreissenid mussels and round gobies vary in density along the international section of the St. Lawrence River as well as those tributary rivers that drain the Adirondack mountains. Densities appear to increase in confluence areas, where seston load is

high, and decrease within tributaries, where water conductivity is very low. As a result, ecosystem impacts of these exotics may be pronounced near tributary confluence areas, where energy and contaminant transfer to sport fish and birds may be elevated. Although these predators may benefit from the additional forage round gobies provide, mercury levels, especially those of sport fish, appear high enough to cause them reproductive problems. As a consequence, resource managers might focus their efforts to regulate fisheries and to limit human fish consumption in confluence areas. *Keywords: St. Lawrence River, Round goby, Exotic species.*

BALTHASAR, A.R., XENOPOULOS, M.A., SPOONER, D.E., and EVANS, R.D., Trent University, 1600 West Bank Drive, Peterborough, ON, K9J 7B8, Canada. **Concentration and Isotope Ratios of Zinc in Streams Along a Gradient of Agricultural Land Use.**

With recent advances in mass spectrometry it is now possible to measure differences in isotopic ratios of metals and track pollution pathways. Here, we used high precision MC-ICP-MS to quantify Zn concentration and isotope ratios in 12 streams in southern Ontario flowing through variable agriculture land use. Zinc isotopic ratios have been used to track pollution derived from mining practices and waste but less is known about how fertilizer and pesticide pollution can affect Zn ratios and fractionation based on geochemical and biological processes. We measured and traced the potential accumulation and isotope ratio variation of zinc in an indicator species *Unionoida* (freshwater mussels) along a gradient of agriculture. Preliminary analysis on water samples show that water column zinc is variable across sites. Several other metals were highly correlated with agricultural land use, including molybdenum which ranged from 0.02 ppb to 0.16 ppb with increasing monoculture. The study will contribute to the understanding of how land use can affect amounts of metals leached from soils into streams and lakes. The techniques used in this project will also contribute to how metal accumulation in aquatic organisms may be facilitated by nutrient loading and landscape changes associated with agriculture. *Keywords: Metals, Agriculture, Stable isotopes, Mussels.*

BANTELMAN, A.[1], EDWARDS, W.J.[1], SOSTER, F.[2], SCHLOESSER, D.W.[3], and MATISOFF, G.[4], [1]Department of Biology, Niagara University, Lewiston, NY, 14109; [2]Department of Geosciences, DePauw University, Greencastle, IN, 46135; [3]USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105; [4]Department of Geological Sciences, Case Western Reserve University, Cleveland, OH, 44106. **Internal nutrient recycling by burrow irrigation in Chironomus spp.: implications for eutrophication.**

Chironomus spp. were shown to have an impact on Lake Erie hypoxia via burrow irrigation and that impact is altered by environmental conditions. However, it was unclear how changing seasonal environmental conditions alter burrow irrigation and thus their potential impact on recycling of nutrients from the benthic sediments. We conducted laboratory experiments to determine the effects of changing oxygen, food and temperature on both burrow irrigation activity and nutrient flux from the sediment. 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. Nitrate, ammonia, TP and SRP were measured in both experimental treatments and controls. Higher temperatures resulted in higher pumping activity, but food quantity did not. Low oxygen concentrations resulted in increased irrigation. Increases in irrigation resulted in increased nutrient flux from the sediment, relative to controls. These results indicate changing temperature, oxygen and food availability in the hypolimnion will alter the effects of macrobenthos on nutrient recycling from the sediment. *Keywords: Benthos, Eutrophication, Nutrients.*

BARBIERO, R.P.[1], SCHMUDE, K.[2], LESHT, B.M.[3], RISENG, C.M.[4], WARREN, G.J.[5], and TUCHMAN, M.L.[5], [1]CSC and Loyola Unversity, 1359 W Elmdale #2, Chicago, IL, 60660; [2]University Wisconsin-Superior, 801 North 28th St., Superior, WI, 54880; [3]CSC and University of Illinois Chicago, 845 W. Taylor St., Chicago, IL, 60607; [4]University of Michigan, 440 Church St., Ann Arbor, MI, 48109; [5]US EPA Great Lakes National Program Office, 77 W. Jackson Blvd, Chicago, IL, 60604. **Trends in Diporeia populations across the Laurentian Great Lakes, 1997-2008.**

Diporeia populations have been monitored in all five great lakes by the US EPA since 1997. No *Diporeia* have been found in Lake Erie during the twelve years of our study, corroborating that *Diporeia* is now effectively absent from that lake. Populations have also largely disappeared from shallow (< 90 m) sites in lakes Ontario, Huron and Michigan. As of 2008, mean population densities at deeper (> 90 m) sites in lakes Huron and Michigan were $554/m^2$ and $370/m^2$, respectively, similar to those found in Lake Superior (average = $442/m^2$), while densities were somewhat lower in Lake Ontario (average = $134/m^2$). Deep populations in lakes Michigan and Huron were relatively stable between 2004 and 2008. No evidence of declines was seen in Lake Superior. Regressions between average May chlorophyll concentrations and *Diporeia* densities at deeper (> 90 m) sites in lakes Huron and Michigan were highly significant, and explained a substantial amount of variability (adjusted r^2 for Lake Huron and Lake Michigan = 0.58 and 0.44, respectively, the latter with a one-year time step). We believe that decreases in the supply of spring phytoplankton may have contributed to the declines in deep populations in those lakes. *Keywords: Benthos, Productivity, Diporeia.*

BARNES, R.[1], ROY, J.W.[2], and BICKERTON, G.[2], [1]McMaster University, Hamilton; [2]Environment Canada, Burlington. **Groundwater contaminants affecting urban streams in the Lake Simcoe watershed.**

In this study, we investigated the potential risk posed by groundwater contaminants discharging to two urban streams that drain into Lake Simcoe. These contaminants may pose a direct toxicity threat or lead to eutrophication in the streams, potentially affecting aquatic and riparian plants, benthic organisms and fish spawning areas, with secondary influences on the lake ecosystem. For each stream, groundwater samples from below the stream bed (typically 25-75 cm) were collected using a drive-point mini-profiler at intervals of 10-15 m for 100s-1000s m and were subsequently analysed for a wide range of urban contaminants. This screening technique focuses on detection of potential areas of concern rather than precise quantification of

contaminant concentrations or fluxes. Identified contaminants at both streams included perchlorate, various pesticides (e.g. glyphosate, glufosinate), and elevated levels of nitrate, phosphate, and chloride (may be road salt). Both sites also had samples with artificial sweeteners, suggesting the influence of septic systems or leaking sewers or old landfills. One stream also had multiple locations (along a 500-m section) with detections of chlorinated solvents, specifically trichloroethene (TCE) and its daughter products, and petroleum hydrocarbons, such as benzene, toluene, and naphthalene. *Keywords: Environmental contaminants, Groundwater-surface water interaction, Lake Simcoe, Streams, Urban areas.*

BARTLETT, A.J., BROWN, L.R., and STRUGER, J., 867 Lakeshore Road, P.O. Box 5050, Burlington, ON, L7R4A6. ***In situ* exposures of *Hyalella azteca*: A tool to assess the impacts of pesticide use on freshwater ecosystems.**

Previous studies have shown that *in situ* exposures of *Hyalella azteca* can be used to evaluate the impacts of pesticide use in freshwater streams. This study examines sites in southern Ontario where acetylcholinesterase (AChE) inhibiting pesticides (organophosphates [OPs] and carbamates [CBs]) are consistently measured in surface waters. One-week exposures were conducted in 2008 and 2009 at two agricultural sites (Two-Mile and Vineland Creeks), one urban stream (Indian Creek), and one reference site (Spencer Creek). Two additional agricultural sites were added in 2009: Richardson Creek and Twenty-Mile Creek (at Bailey Bridge). Exposures were conducted monthly during the growing season: once pre-pesticide use (May), four times during peak pesticide use (June-September), and once post-pesticide use (October). Significant mortality and AChE inhibition occurred during peak pesticide use at Two-Mile and Vineland Creeks, where OPs and CBs were consistently measured in surface waters. Significant AChE inhibition also occurred in some cases at sites where survival was not impacted and lower levels of OPs and CBs were measured, which may indicate that AChE inhibition occurs before effects on survival. The validity of using *in situ* methods to evaluate pesticide impacts on freshwater ecosystems will be discussed. *Keywords: Bioindicators, In situ, Amphipods, Acetylcholinesterase, Pesticides.*

BARTON, D.R.[1], EVANS, D.O.[2], and OZERSKY, T.[1], [1]Deptartment of Biology, University of Waterloo, Waterloo, ON, N2L 3G1, Canada; [2]Ontario Ministry of Natural Resources, Trent University, Peterborough, ON, K9J 7B8, Canada. **Changes In The Benthic Invertebrate Community And Trophic Relationships In The Nearshore Of Lake Simcoe Following The Introduction of *Dreissena polymorpha*.**

Dreissena polymorpha was probably introduced into Lake Simcoe in about 1991, and was well-established by 1996, primarily in rocky nearshore areas. We compared air-lift samples of benthic macroinvertebrates and stable isotope analyses of invertebrates and fish collected in 1993 and 2008, to evaluate the impact of zebra mussels on nearshore (2 - 6 m depths) community structure and trophic relationships. No dreissenids were found in 1993. The mean density of *D. polymorpha* was 3439 individuals m^{-2} in 2008, and the densities of other invertebrates were 40x greater than in 1993. With the exception of substantial shifts in the absolute abundance and species composition of the amphipod assemblage, there was no evidence of change in overall

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diversity or the relative abundances of the major groups of invertebrates. Stable isotopes indicated a less diverse trophic base in 2008, with most consumers depending primarily on mussel biodeposits and periphyton. Our results provide strong support for the nearshore shunt hypothesis and the status of dreissenid mussels as "ecosystem engineers". *Keywords: Lake Simcoe, Food web, Benthos, Dreissena, Stable isotopes.*

BARTON, N.T.[1], GALAROWICZ, T.L.[1], CLARAMUNT, R.M.[2], and FITZSIMONS, J.D.[3], [1]Central Michigan University, Mount Pleasant, MI, 48858; [2]Charlevoix Fisheries Research Station, 96 Grant Street, Charlevoix, MI, 49720; [3]Department of Fisheries and Oceans, Bayfield Institute, Burlington, ON, L7R 4A6. **A Comparison of Egg Bag and Funnel Estimates of Native Fish Egg Deposition Rates in Grand Traverse Bay, Lake Michigan.**

Native Great Lakes fishes such as lake trout (Salvelinus namaycush) and lake whitefish (Coregonus clupeaformis) use reefs for spawning in the Great Lakes. These hard substrates are difficult to sample using traditional sampling gears. 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 efficiencies of the egg bags and funnels was measured by seeding each gear type with artificial eggs of lake trout and lake whitefish in situ. Artificial egg recovery data suggests similar recoveries in egg bags and egg funnels; however, egg funnels were more useful because they could be checked weekly while the egg bags collected one sample between deployment and retrieval. Estimates of natural egg deposition from egg bags were higher than the funnel estimates, likely resulting from gear avoidance or other limitations in 2008. However, in 2009, further modifications were made upon the egg funnels to decrease gear avoidance. 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: Gear comparison, Egg deposition, Trout.*

BASSINGTHWAITE, M.F.[1] and HELKA, J.[2], [1]Cole Engineering Group Ltd., 100-100 Renfrew Drive, Markham, ON, L3R9R6; [2]City of Hamilton, 700 Woodward Ave, Hamilton, ON, L8H6P4. **The Enhancement of Windermere Basin - Sediment Management, Habitat Restoration and Aesthetic Improvement within the City of Hamilton.**

Windermere Basin, located at the outlet of Red Hill Creek to Hamilton Harbour in the City of Hamilton, was re-constructed in 1990 to act as a sediment trap to prevent sedimentation in downstream shipping routes near Pier 25 within Hamilton Harbour. The Basin has reached its capacity as a sediment trap and is no longer functioning effectively. In its current state, the Basin is degraded habitat with low diversity. Enhancement of the Basin is proposed by the City through sediment management and construction of a wetland. In order to regulate water quality, the wetland area will be isolated from Red Hill Creek by construction of a dyke. Distinct habitat zones will be created in the wetland supporting a wide range of vegetation and wildlife species. Existing sediment will be capped with clean fill and planted with native wetland vegetation. A fishway will also be installed to assist entry of desired species while discouraging undesirable species. Ecological success of the project will be measured by growth of diversified aquatic and terrestrial habitat. The Enhancement of Windermere Basin will create passive recreational

opportunities by tying into existing trails and habitat corridors and contribute to the delisting of Hamilton Harbour as an Area of Concern. *Keywords: Coastal wetlands, Biodiversity, Sediments.*

BAZZARD, A.R.[1] and BOURBONNIERE, R.A.[2], [1]McMaster University, School of Geography and Earth Sciences, 1280 Main Street, Hamilton, ON, L8S4L8; [2]Environment Canada, National Water Research Institute, Burlington, ON, L7R4A6. **Carbon Dioxide and Nitrous Oxide Accumulation in Lake Erie's Central Basin Hypolimnion.**

In the 1960s and 1970s phosphorus loadings to Lake Erie promoted increased productivity which led to hypolimnetic anoxia, particularly in the central basin. Although significant efforts reduced anthropogenic inputs, the central basin continues to develop hypolimnetic hypoxia during summer stratification. To determine the course and extent of greenhouse gas (GHG) accumulation in the central basin hypolimnion, samples collected on ten cruises from January – October 2009 were analyzed for dissolved CO_2, N_2O, NO_3^-, Dissolved Oxygen (DO) and other water chemistry parameters. We observed that decreases in DO and NO_3^- concentrations were accompanied by increases in CO_2 and N_2O in the hypolimnion. Sustained hypoxia in the hypolimnion promoted the accumulation of CO_2 and N_2O until it was interrupted by a period of cold weather in July and August. This phenomenon is pronounced in the central basin, non-existent in the western basin and subdued in the eastern basin. *Keywords: Hypolimnion, Oxygen, Greenhouse gases.*

BECHLE, A.B.[1], WU, C.H.[1], and LIU, P.C.[2], [1]1415 Engineering Drive, 1269D Engineering Hall, Madison, WI, 53706; [2]NOAA/GLERL 4840 S. State Rd, Ann Arbor, MI, 48108. **Automated stereo imaging system for three-dimensional surface wave measurements in Lakes.**

Instantaneous and irregular wave phenomenon such as freak waves are insufficiently characterized by conventional sensors. The spatial and temporal measurements necessary to describe these processes are attained with stereo imaging, a highly flexible remote sensing technique. Using an automated trinocular stereo imaging system (ATSIS), a stereo-triplet of images is analyzed using a triangulation procedure to produce a 3D map of the water surface. When sequential time series of stereo-triplet video are processed, four-dimensional wave data can be obtained to reveal non-stationary wave phenomenon in a random sea state. Several examples including freak waves in Lake Superior, breaking waves and capillary waves in Lake Mendota, and waves interacting with ice floes will be given in this talk. Finally an innovative virtual wave gauge arrays will be introduced so that real-time wave monitoring can be realized. *Keywords: Waves, Remote sensing, Measuring instruments.*

BELETSKY, D.[1], SCHWAB, D.[2], RAO, Y.R.[3], HAWLEY, N.[2], VANDERPLOEG, H.[2], and BELETSKY, R.[1], [1]CILER, University of Michigan, 4840 South State Rd., Ann Arbor, MI, 48108; [2]Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108; [3]National Water Research Institute, Burlington, ON. **Thermocline of Lake Erie.**

In most thermally stratified lakes, the summer thermocline has the shape of a "dome", being shallower offshore and deeper nearshore. Lake-wide observations of subsurface temperature at several moorings in central Lake Erie in 2005 revealed a traditional dome-shaped thermocline in May-early July and an unusual "reversed" or "bowl-type" shape of the thermocline during about half of the time during the late July-September period, with deeper thermocline in the middle of the lake and shallower thermocline nearshore. We also note that currents measured in the central basin when the bowl-shaped thermocline was observed were strongly anticyclonic, forming a single basin-wide gyre. Analysis of 2007 data confirmed these findings, although the occurrence of a bowl-shaped thermocline was less frequent than in 2005. We hypothesize that the unusual bowl-shaped thermocline is a result of the so-called Ekman pumping (upwelling nearshore, downwelling offshore) during passages of atmospheric anticyclones intensified over the lake surface in summer. *Keywords: Hydrodynamic model, Coastal processes, Lake Erie.*

BELLAMY, S.R.[1], VAN VLIET, D.J.[1], COLLIN, S.B.[1], WALKER, R.[2], MORTSCH, L.[3], GARRAWAY, M.[4], and MILFORD, L.[4], [1]AquaResource Inc., Waterloo; [2]EBnFLO Environmental, Waterloo; [3]Environment Canada, Waterloo; [4]Ministry of Natural Resources, Peterborough. **Development of a Climate Change Hydrologic Assessment Framework for the Province of Ontario.**

The Province of Ontario has developed a comprehensive guidance manual for the assessment of climate change impacts on surface water and groundwater resources. This guide is aimed towards water resources engineers and hydrologists responsible for watershed-based water budget studies under the Clean Water Act (2004) as well as similar types of investigations such as subwatershed planning studies and hydrologic impact assessments. The guidelines are developed specifically to aid in the estimation of the impact of climate change on hydrologic processes relating to precipitation, evapotranspiration, runoff, and groundwater recharge. This presentation provides a brief summary of several aspects related to the guidance document, including: the recommended guidelines which includes a methodology for representing the predictive variability of water budget parameters associated with alternative Global Climate Model scenarios; a summary of a case study; and current efforts to develop a database of climate scenarios for climate stations across the Province. *Keywords: Climate change, Hydrologic budget, Watersheds.*

BENNINGTON, V.[1], MCKINLEY, G.A.[1], WU, C.[2], DESAI, A.[1], URBAN, N.[3], and KIMURA, N.[1], [1]University of Wisconsin-Madison, Atmospheric and Oceanic Sciences, Madison, WI, 53706; [2]University of Wisconsin-Madison, Civil and Environmental Engineering, Madison, WI, 53706; [3]Michigan Technological University, Civil and Environmental Engineering, Houghton, MI, 49931. **Lake Superior Circulation 1979-2006: a Modeling Study.**

From direct observations and previous modeling studies, we have a limited understanding of the climatology and variability of large-scale circulation in Lake Superior. We use a 3D hydrodynamic model (MITgcm) at 2km horizontal resolution to study the structure and driving mechanisms of Lake Superior circulation from 1979 to 2006. The model is forced by 3-hourly

atmospheric conditions from the North American Regional Reanalyis Project. Modeled thermal structure and circulation compare well to observations throughout the lake. We examine lake-wide circulation patterns above and below the thermocline; the relative effects of temperature gradients, wind, and bathymetry on currents; and trends in lake temperature, speed, evaporation, and mixed layer depth. We find temperature gradients control currents near shore, but winds drive currents offshore. From a uniform bathymetry simulation, we conclude topographic effects are responsible for small-scale structures in the open lake and set up nearshore-offshore temperature gradients. In the 28 years, wind speed increases 0.18 m/s/decade causing an increase in surface speeds of 0.37 cm/s/decade. Lake surface temperatures increase 0.34°C/decade. Increasing winds and surface temperatures counteract each other, causing mixed layer depths to remain unchanged. We find no trend in evaporation. *Keywords: Hydrodynamic model, Large-scale circulation, Lake Superior, Climatology, Water currents.*

BENOIT, N.B.[1] and BURNISTON, D.[1], [1]Ontario Ministry of the Environment, 125 Resources Rd, Etobicoke, ON, M9P 3V6; [2]Water Quality and Surveillance Office, Ontario Environment Canada, 867 Lakeshore Rd, Burlington, ON, L7R 4A6. **Tracking PCB Contamination in Great Lakes Tributaries.**

Project Trackdown is an investigative monitoring program aimed at tracking sources of PCB contamination in Great Lakes tributaries. Throughout the development of the program, our approach has focused on using an assemblage of matrices in a concentration-based weight of evidence approach, combined with simple chemometric analyses of PCB congener profiles to derive information on potential ongoing and locally controllable sources of contamination. The program has also emphasized defining background conditions in typical urban areas, and differentiating these from ongoing and locally controllable sources of contamination to Great Lakes tributaries. A collaborative initiative between the Ontario Ministry of the Environment and Environment Canada, Project Trackdown has successfully identified several areas of PCB contamination that have led to substantial cleanup efforts aimed ultimately at reducing PCB contamination to the Great Lakes. *Keywords: Watersheds, Pollution sources, PCBs.*

BERGER, A.M. and JONES, M.L., Department of Fisheries and Wildlife, Michigan State University, East Lansing, MI, 48824. **Decision Analysis and the Central Role of Uncertainty in Quantitative Models Used to Evaluate Management Strategies.**

Applications of decision analysis methods to resource management are becoming more commonplace and are often used to identify management strategies that perform well despite uncertainties about the managed system. These approaches often use quantitative models to forecast the expected outcome of different management actions. A major advantage of using quantitative models is the ability to explicitly incorporate uncertainty into the process. Uncertainties are pervasive in resource management and can have important effects on the performance of management options. Explicitly including uncertainty in models can be very useful for identifying the most robust management strategies to uncertain future system states. Decision analyses should incorporate, in addition to key uncertainties, objectives that include the full suite (biological, economic, social, and cultural) of stakeholder values. This also helps

inform good decisions, by allowing explicit consideration of the trade-offs that commonly exist among objectives. We review the role of uncertainty in developing management strategies and highlight several quantitative approaches used to aid complex resource management decisions. *Keywords: Policy making, Fish populations, Fish management.*

BETZHOLD, L.D. and MATAOSKY, R.L., 2234 S. Hobson Ave, Charleston, SC, 29412. **Topographic and Bathymetric Inventory for the Great Lakes.**

The Topographic and Bathymetric Data Inventory, newly available for the Great Lakes region, is a national-scale online viewer that serves as an index to the best-available elevation data sets by region. The Inventory is designed to increase awareness of existing elevation data sets, identify gaps in coverage, and encourage collaboration for collection of new data sets. Since data sets are often hosted in many locations or are not directly accessible, the Inventory seeks to provide a snapshot of data availability, accessibility, type, and quality. Users can zoom in to an area on the map and click on the data set to access up to 20 attributes, including vertical accuracy, datums, collection date, and point spacing. This work was completed with input from several federal, state, local, and regional groups and with support from EPA's Great Lakes Restoration Initiative. The Topographic and Bathymetric Data Inventory can be accessed online at www.csc.noaa.gov/digitalcoast/tools/topobathy/index.html. *Keywords: Benthos, Coasts, Coastal engineering.*

BHAGAT, Y. and RUETZ III, C.R., Annis Water Resources Institute, Grand Valley State University, 740 West Shoreline Drive, Muskegon, MI, 49441. **Assessing patterns of spatial and temporal variation of fish assemblages in a drowned river mouth (DRM) system of Lake Michigan.**

Drowned river mouth (DRM) lakes serve as unique ecosystems to investigate patterns of fish community composition because they contain wetland-type habitats as well as open lacustrine areas and as such, can serve as refugia for juveniles, act as spawning grounds, and provide alternate food sources for several species. Muskegon Lake, a DRM system connected to Lake Michigan, has received much focus in recent years due to its history of anthropogenic influences and its subsequent classification as an Area of Concern. Yet, little is known about the spatial and temporal variation in species assemblages and how it relates to environmental variation. We used overnight fyke nets to sample fish communities at four littoral sites in the spring, summer and fall of 2003-2009. Ordinations showed that fish assemblages most strongly differed by season and location sampled but were also influenced by conductivity, dissolved oxygen, temperature and macrophyte coverage. While lepomis sp. were positively correlated with macrophyte density and fall sampling season, round gobies were negatively correlated with temperature and pH. Overall, our results suggest that patterns in species distribution and abundance respond more strongly to short term, seasonal variation rather than long term annual variation in the environment. *Keywords: Fish, Drowned river mouth systems, Lake Michigan, Environmental variation, Distribution patterns, Temporal and spatial patterns.*

BHAVSAR, S.P., AWAD, E., MAHON, C., PETRO, S., VAILLANCOURT, A., and FLETCHER, R., Ontario Ministry of the Environment, Environmental Monitoring Reporting Branch, Toronto, ON, M9P 3V6.
Risk-based fish consumption advisories for the Canadian Great Lakes (2009-2010).

About 4-5 million adults living in the U.S. and Canada consume sport fish from the Great Lakes. Risk-based fish consumption advisories are issued to advise the public on eliminating/restricting consumption of certain fish species/sizes in order to avoid adverse health effects due to elevated contaminant levels. To establish how restrictive the advisories are and which contaminants are causing these restrictions on a lake-wide as well as a smaller scale basis for both the general and sensitive population (women of child-bearing age and children under 15), we examined fish consumption advisories issued by the Ontario Ministry of the Environment through the 2009-2010 Guide to Eating Ontario Sport Fish. The restrictions are generally in the order of Lakes Superior < Huron < Erie < Ontario and are primarily caused by PCBs and secondarily by dioxins/furans and mercury. Toxaphene is the only other contaminant causing restrictions for Lake Superior fish (<8% contribution to the restrictions). Restrictions for salmon species, which are expected to contain relatively higher levels of beneficial Omega-3 fatty acids, generally ranged from 33-100% (except 9% for pink salmon in Superior) with little difference for the general and sensitive populations. *Keywords: Fish, Fishing, Environmental contaminants.*

BIDDANDA, B.A., KENDALL, S.T., STRICKLER, E.A., WEINERT, M.E., DEFORE, A.L., and DRIZA, K.M., Annis Water Resources Inst., Grand Valley State U, 740 W. Shoreline Dr, Muskegon, MI, 49441.
Balance of Production and Respiration in Lake Michigan: Insights into Land-Lake Linkages and the Carbon Cycle.

Respiration (R) and primary production (P) are the major pathways for carbon and energy flow in ecosystems. A series of measurements of planktonic R made in southeastern Lake Michigan over the past decade demonstrate that the major fate of the P in this large lake is indeed R. Annually, input of nutrients and carbon from the watershed and major rivers may support substantial autotrophy (~20%) as well as heterotrophy (~10%) in southern Lake Michigan. Thus, microbial lake plankton (autotrophs and heterotrophs) link terrestrial nutrients and carbon to aquatic metabolism. Other trends that were observed include decreasing R (on a volumetric basis) and increasing R (relative to ambient primary production) along a gradient of decreasing P extending from land to lake in this Great Lake watershed. 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. It appears that the open lake system tend to be a source of carbon in the summer, whereas the nearshore ecosystem tends to be a sink for carbon especially during the winter. In this paper, we discuss some of the implications of these observed trends to our understanding of carbon cycling and food webs in this Great Lakes basin. *Keywords: Biogeochemistry, Carbon cycle, Lake Michigan.*

BISHOP, R.[1], SNODGRASS, W.J.[2], DEWEY, R.[3], CHARRON, A.[4], LI, A.[2], and D'ANDREA, M.[2], [1]MMM Group Limited, 100 Commerce Valley Drive West, Thornhill, ON, L3T 0A1; [2]City of Toronto, Metro Hall, 55 John Street, 18th Floor, Toronto, ON, M5V 3C6; [3]City of Toronto, Metro Hall, 55 John Street, 27th Floor, Toronto, ON, M5V 3C6; [4]BPR Inc., 1100 Burloak Drive, Suite 301, Burlington, ON, L7L 6B2.
Forecast Receiving Water Response to alternative Control Levels for Combined sewer overflows discharging to Toronto's Inner harbour.

This paper evaluates the role that different levels of control of combined sewer overflows have in addressing the recreational water quality objectives for the Inner harbour of the Toronto AOC. Three models were used to establish the predictive methodology – the Infoworks model to address rainfall – runoff processes for combined sewer overflows and storm sewer discharges within the combined sewer service area, the HSPF model to evaluate runoff and water quality from separated storm sewer areas and compute river water quality, and the MIKE 3 computer code to evaluate Lake Ontario water quality. Each model was calibrated with E Coli levels observed respectively in discharges, instream, and in the Inner Harbour and near-by beaches. Cost – effectiveness curves have been constructed, and used to evaluate two alternative Inner Harbour response indices – fraction of surface area under Blue Flag status, and portion of swimming season above recreational objectives. Economic analysis leads to the recommendation that one overflow per year strategy should be pursued, rather than the lower level of control of 90 % volume control, which is the minimum provincial environmental requirement. *Keywords: Water quality.*

BLACK, T.J., 10701 Murphy Road, Roscommon, MI, 48653.
Karst Water Input to Lakes Huron and Michigan.

Over 200 major surface and ground water swallowing sink holes are visible in Michigan. Three discharging sink holes in Lake Huron have been studied. One known as the El Cajon Bay Sink has a discharge over 10 cu ft/sec (Curl, 1980) which matches the volume of the only measured swallow at Rainy Lake (MDNR, 1982). This author estimates that the three studied discharge points account for less than one percent from the known karst system to lakes Michigan and Huron. The inland swallows represent significant bypass and divergence of surface and ground water through a major karst system. Swallows occur from near lake level near the shoreline to 290 feet above 20 or more miles inland (50 miles along the sink hole trend). One stream swallow is 10 miles from the shoreline and less than 50 ft above lake level, an underground gradient of less than 5 ft/mile. Swallowed water travels vertically downward to the Detroit River Group of rock formations (over 1,000 ft in areas) where gypsum and other minerals are dissolved. It then flows laterally to the lakes and discharged as far as 3.4 miles (13.5 Km) from shore. Water flowing out of these sink holes was uniformly DO 0.1-2 and sulfate near 1,600 mg/l (Biddanda, 2006; Morrow, 1967). Work is progressing to identify the locations, flow volume, and water chemistry of more submerged sink holes. *Keywords: Geochemistry, Karst, Lake Huron, Ground water, Water quality.*

BLUKACZ, E.A.[1] and KOOPS, M.A.[2], [1]Environment Canada, Toronto, ON, Canada; [2]Fisheries and Oceans Canada, Burlington, ON, Canada. **A Mass-Balance Remediation Approach towards Reaching Delisting Targets in Areas of Concern.**

The International Joint Commission (IJC) identified the Bay of Quinte as an Area of Concern (AOC) due to its degraded ecosystem. A Remediation Action Plan (RAP) was established with delisting targets including the goals of decreasing phosphorous loading and restoring the upper (fish and wildlife) and lower (phytoplankton, zooplankton, and benthic invertebrates) trophic levels. The ultimate goal is to delist the Bay of Quinte as an AOC. To date, phosphorous control efforts have reduced phytoplankton abundance; however invasion by non-native species (e.g., zebra mussels, cormorants) has led to further disruption. We use a mass-balanced ecosystem modelling approach to examine the feasibility of reaching the current delisting targets for the upper Bay of Quinte. We modified an Ecopath model representing the post-zebra mussel invasion period (1995-2002). To address specific delisting targets, we modified the functional groups in the original model to examine how readily we can re-balance the model under the current remediation plan. The re-balanced model will help determine whether the current targets are feasible and help revise targets if necessary. *Keywords: Ecosystem modeling, Recovery targets, Bay of Quinte.*

BLUKACZ, E.A.[1], SPRULES, W.G.[2], and SHUTER, B.J.[3], [1]Environment Canada, 4905 Dufferin St., Toronto; [2]University of Toronto at Mississauga, 3359 Mississauga Rd N, Mississauga, ON; [3]University of Toronto, 25 Willcocks St., Toronto. **Wind-driven patchiness; spatial-patterns, trophic interactions and monitoring implications.**

Wind creates, maintains, and destroys plankton patchiness which can affect predator-prey spatial overlap and consequently trophic interactions. To assess these relationships, we repeatedly sampled the same linear transects in two basins of Lake Opeongo (ON, Canada) over 100 times at various times of day and many days throughout the summer so we could follow spatial patterns under changing wind conditions. Spatially explicit in situ simulations that include activity costs associated with feeding were used to examine the effects of chlorophyll patchiness on the energy gain in different zooplankton communities. Simulations were repeated for all combinations of zooplankton size-classes (bulk, small, and large) and for each simulated combination, a spatial energetic differential (SED) was estimated. Large zooplankton had the greatest SED with a maximum increase of 20% while small zooplankton showed a marginal increase. High SED were frequent when zooplankton and chlorophyll were positively correlated as shown by wavelet analysis, indicating that predator-prey spatial overlap is an important determinant of high SED values. We discuss the implications that such patterns can have on monitoring both nearshore and offshore spatial patterns. *Keywords: Waves, Zooplankton, Plankton.*

BOCANIOV, S.A.[1], LEON, L.F.[1], SILSBE, G.M.[1], ZHAO, Y.[2], SMITH, R.E.H.[1], and LAMB, K.[3], [1]Department of Biology, University of Waterloo, Waterloo, ON, N2L3G1, Canada; [2]Aquatic Research and Development Section, Ontario Ministry of Natural Resources, Wheatley, ON, N0P2P0, Canada; [3]Applied Mathematics, University of Waterloo, Waterloo, ON, N2L 3G1.

Modelling the three dimensional spatial dynamics of nutrients, phytoplankton and dissolved oxygen in Lake Erie.

Hypoxia continues to be a concern in many large aquatic ecosystems, including Lake Erie. In large systems, the distribution of hypoxic water masses can be very dynamic and can have serious ecological consequences. One such consequence is fish mortality due to upwelling of hypoxic water, which is suspected to occur in parts of the central basin of Lake Erie. We show here that a three dimensional model (ELCOM-CAEDYM) captures the major patterns of variability in phytoplankton and nutrients (important drivers of hypoxia) in two years of observation (2002 and 2005) in Lake Erie. Observations of dissolved oxygen (DO) concentration profiles provided snapshots of the vertical distributions of DO and the seasonal progression of hypolimnetic hypoxia in the central basin of the lake. We document here the correspondence between modeled and observed DO. We then use the model to characterize the spatial dynamics of DO and examine the potential for intrusion of hypoxic layers into surface and/or nearshore waters. _Keywords: Nutrients, Model studies, Lake Erie._

BOEGMAN, L.[1] and YERUBANDI, R.R.[2], [1]Department of Civil Engineering, Queen's University, Kingston, ON; [2]National Water Research Institute, Environment Canada, Burlington, ON.
Process oriented modeling of Lake Ontario hydrodynamics.

A three-dimensional hydrostatic Reynolds-averaged Navier-Stokes equation model has been applied to simulate the ice-free hydrodynamics of Lake Ontario during 2006. The model is compared to field observations to assess its ability to reproduce the fundamental physical processes driving hydrodynamics. The model correctly simulates the seasonal stratification, surface seiches and internal Poincaré waves without adjustment. Scaling of inflows is required to reproduce water levels. Surface topographic and internal Kelvin waves are simulated; however, these motions are under-resolved with the 2 km horizontal grid used in this study. _Keywords: Lake Ontario, Hydrodynamic model, Hydrodynamics._

BOEHRER, B., Helmholtz Centre for Environmental Research - UFZ, Brueckstrasse 3a, Magdeburg, D-39114, Germany.
Lakes density stratified by biogeochemical processes.

Biogeochemical reactions change the composition of the dissolved substances. Solutes may be transformed into insoluble forms, and hence be removed from the water column. Redissolution may enhance the concentration of dissolved substances in other parts of the lake. In some cases, gradients are created which suffice to inhibit the vertical full circulation of the lake during the annual cycle. Such lakes are termed biogenically, internally or geochemically meromictic. A small number of geochemical cycles are known to produce meromixis. We present an overview of these known processes, such as oxic decomposition and iron meromixis. We show data about special stratification and the dynamics of the chemocline over several annual cycles. Finally, the reactivity of dissolved substances even enhances the double diffusive convection in the deep water body, that under favourable circumstances, a full monimolimnetic overturn can occur. This overturn redistributes the solutes in the monimolimnion and hence is of great importance for the evolution of water quality in the entire lake. Reference: Boehrer, B., S.

Dietz, C. von Rohden, U. Kiwel, K. D. Jöhnk, S. Naujoks, J. Ilmberger, and D. Lessmann (2009), Double-diffusive deep water circulation in an iron-meromictic lake, Geochem. Geophys. Geosyst., 10, Q06006, doi:10.1029/2009GC002389. *Keywords: Hydrodynamics, Meromixis, Biogeochemistry, Physical limnology, Iron, Density stratification.*

BOOTSMA, H.A.[1] and HECKY, R.E.[2], [1]Univeristy of Wisconsin-Miwlaukee, 600 E. Greenfield Ave., Milwaukee, WI, 53204; [2]University of Minnesota-Duluth, 2205 East Fifth Street, Duluth, MN, 55812. **Mechanisms Controlling Carbon Dynamics in Lake Malawi.**

Although photosynthetic rates have been measured in many tropical lakes, few studies have examined other carbon input and output processes in these systems. We present the results of a multi-year study in which photosynthesis, river inputs, atmospheric deposition, sedimentation, and burial were measured in Lake Malawi. High organic carbon concentrations and high particulate:dissolved organic carbon ratios in rivers reflect a large impact of land-use practices on allochthonous carbon inputs . However, most organic carbon input to the lake is via algal photosynthesis. A comparison of inputs and outputs indicates that photosynthesis and respiration are approximately balanced, with permanent burial representing about 10% of total organic carbon input. Dissolved inorganic carbon profiles suggest that the lake is a carbon sink during the productive period following mixing, and a carbon source to the atmosphere during the stratified season. Sediment profiles suggest that carbon burial is tightly coupled to silica burial. We present a simple model to illustrate how the ultimate fate of carbon (burial versus respiration and degassing) may be controlled by silica dynamics. *Keywords: Lake Malawi, Biogeochemistry, Carbon.*

BOOTY, W.G.[1] and BOWEN, G.S.[2], [1]867 Lakeshore Rd., Burlington, ON, L7R4A6; [2]5 Shoreham Drive, Downsview, ON, M3N1S4. **Watershed Nutrient and Sediment Loadings on the Canadian Side of Lake Ontario.**

The nearshore of Lake Ontario is a valued amenity. It is an area of contrasting uses, including public green spaces, Provincially Significant Wetlands, recreational boating, municipal and private sector infrastructure related to the treatment of wastewater and potable water, and the generation of electric power. There is a shared interest in the health of the nearshore areas of Lake Ontario. In order to understand conditions in the nearshore, estimates of contaminant loads and watershed pollutant transport mechanisms are required. As part of the 2008 International Special Year of Study for Lake Ontario, Environment Canada and the Toronto and Region Conservation Authority have completed watershed loadings analysis for six representative tributaries to the Canadian side of Lake Ontario. For the Lake Ontario Drinking Water Collaborative Study, we previously developed estimates of pollutants loads for Canadian tributaries between the Niagara River and Prince Edward County, based upon event mean concentration and unit area methods. These load estimates have been verified with 2008 and 2009 sampling data and our revised estimates will be compared with previous published studies for the Great Lakes. *Keywords: Nutrients, Lake Ontario, Watersheds.*

BOSCARINO, B.T.[1], RUDSTAM, L.G.[1], WALSH, M.G.[2], and LANTRY, B.F.[2], [1]900 Shackelton Point Road, Cornell Biological Field Station, Bridgeport, NY, 13030; [2]USGS Lake Ontario Biological Station, 17 Lake Street, Oswego, NY, 13126.
Substrate preference and benthic predator avoidance responses of Great Lakes mysids.

We examine the substrate preferences of both species of Great Lakes mysid shrimp, *Mysis diluviana* and *Hemimysis anomala*, and determine how these preferences are altered by both light and predator presence. *Mysis* showed no substrate preference when given the choice of quagga mussel or sandy bottoms under dark conditions in the laboratory, but strongly preferred sandy substrates under simulated daytime light conditions. Alternatively, *Hemimysis* preferred sandy bottoms relative to quagga mussel, rock or cobble substrates in the dark only. *Hemimysis* shifted from preferring sandy substrates to rocky habitats in the presence of either pumpkinseed sunfish or round goby predators or in lighted conditions. Rocky habitat was most preferred when both light and fish were present. *Mysis* also responded to fish by choosing positions in the water column that were as far away as possible from their predators. This shift was even more pronounced under simulated daylight conditions relative to complete darkness. These results suggest that both species of Great Lakes mysids respond to predators by selecting habitats that either provide cover or are furthest away from fish, but differ in terms of their habitat preferences in lighted versus dark conditions in the absence of predators. *Keywords: Habitats, Predator avoidance, Benthos, Invasive species, Experimental design.*

BOSCH, N.S.[1], ALLAN, J.D.[2], HAN, H.[3], and RICHARDS, R.P.[4], [1]Grace College, 200 Seminary Drive, Winona Lake, IN, 46590; [2]University of Michigan, 440 Church Street, Ann Arbor, MI, 48109; [3]University of Michigan, 440 Church Street, Ann Arbor, MI, 48109; [4]Heidelberg University, 310 E. Market Street, Tiffin, OH, 44883.
Using the Soil and Water Assessment Tool (SWAT) to Evaluate the Impact of Agricultural BMPs on Riverine Nutrient Export to Lake Erie.

We used the Soil and Water Assessment Tool (SWAT) applied to six watersheds draining into Lake Erie to simulate implementation of various agricultural best management practices (BMPs). The SWAT watershed models were calibrated and validated for stream discharge and water quality parameters using data from 1998-2005 by using time series plots and statistical measures to verify model predictions. The models were calibrated and validated against daily flow measurements and near-daily sediment and nutrient concentration measurements near the watershed outlets. Simulated hydrology and water quality parameters closely resembled observed data overall. For a number of BMP scenarios we predict changes in daily and annual streamflow and sediment and nutrient loads in river export. SWAT scenarios showed that the implementation of agricultural BMPs had a marked effect on sediment and nutrient export from all watersheds. Furthermore, certain BMPs were shown to be much more effective at reducing riverine sediment and nutrient fluxes than others. For example, we predicted that adding 10 m grass filter strips to agricultural land in one watershed would result in 22%, 27%, and 3% reductions in annual river loads for total phosphorus, total nitrogen, and sediment respectively. *Keywords: Lake Erie, Agricultural BMPs, Watersheds, SWAT, Nutrients.*

BOUCHARD, R.R.[1] and MOORE, L.[2], [1]Regional Municipality of Peel, Brampton, ON, L6T 4B9; [2]Ontario Clean Water Agency, Toronto, ON.
The "Collaborative" - Purpose, Structure and Objectives.

The Collaborative Study to Protect Lake Ontario Drinking Water identifies and evaluates both local and lake-wide drinking water hazards. This Collaborative includes 19 municipalities (population of 6 million) in the Province of Ontario, stretching from Niagara Region to Prince Edward County, as well as 9 Source Protection Authorities. Scientists from government, universities and consultants support the Collaborative. The Ontario Ministry of Environment funded Phase 1 and 2 technical studies to support the development of source protection plans for each member of the Collaborative. The Phase 3 study was initiated in 2009 to address rules released by the Ontario Ministry of Environment in November 2008. Studies have focused on: 1)Lake Ontario physical processes and lake-wide hydrodynamic modeling; 2)Lake Ontario Watershed/Tributary Pollutant Loading Studies; 3)Pathogen monitoring and source tracking; and 4)Spill Scenario Modeling for Identification of Drinking Water Issues and Threats. The Collaborative is a model of cooperative effort and is making a contribution to sound decision making on protection of Lake Ontario as a critical source of drinking water. *Keywords: Drinking water, Collaboration, Lake Ontario, Management.*

BOUFFARD, D.[1], BOEGMAN, L.[1], and YERUBANDI, R.[2], [1]Civil Engineering Department, Queen's University, Kingston, ON, K7L 3N6, Canada; [2]National Water Research Institute, Burlington, ON, K7LR 4A6, Canada.
Spatial and temporal variability of turbulent hot spots in Lake Erie.

Recent temperature microstructure profiles from central Lake Erie have shown more unstable small scale density inversions than expected near the thermocline. These observations raise questions about the required spatial and temporal sampling to capture mixing events. Data is presented from two intensive measuring campaigns during the summers 2008/2009 in Lake Erie. The primary objective of the study is to investigate the spatial and temporal variability of turbulent events with respect to two processes. First, the role of the lateral boundaries are demonstrated with an increase of unstable profiles in the nearshore region. Second, the question of enhanced turbulence induced by the large internal wave is addressed. The main wind driven oscillation was identified as a Poincaré wave and overturning events are in phase with the crest of the wave. Gradient Richardson numbers in this region were not below the canonical 1/4 value for instability during these events. We believe that the spatial (1 m) and temporal (15 min) averaging associated with the resolution of the ADCP prevented the instrument from capturing the low Ri thin layers that have been observed by others to be associated with shear instability. For this reason, we investigate the link between induced turbulence and large scale internal wave activity using Thorpe scale. *Keywords: Lake Erie, Patchy mixing, Measuring instruments.*

BOWEN, G.S.[1] and BOOTY, W.G.[2], [1]Toronto and Region Conservation Authority, 5 Shoreham Drive, Downsview, ON, M3N 1S4; [2]Environment Canada Canada Centre for Inland Waters, National Water Research Institute, 867 Lakeshorer Road PO Box 5050, Burlington, ON, L7R

4A6. **Watershed Pollutant Loadings Estimates Developed for Lake Ontario Intake Protection Zone Studies.**

Lake Ontario is the source of drinking water for over 6 million residents. There are special provisions under Ontario's Clean Water Act, 2006, the Provincial Source Water Protection Legislation, to ensure that Lake Ontario continues to be a safe and reliable supply. This paper will describe water quality studies conducted by Environment Canada and the Toronto and Region Conservation Authority for the Lake Ontario Drinking Water Collaborative and the Source Protection Areas for Lake Ontario to provide estimates of watershed pollutant loading to Lake Ontario. This paper will describe how the loading estimates will be incorporated into the Drinking Water Intake Protection Zone 3 regulatory approach for the Great Lakes. Based upon sampling completed in 2008 and 2009, differences in pollutant contribution due to watershed size and land use patterns will be discussed for watersheds entering the lake on the Canadian side, between the Niagara River and Prince Edward County. Comparisons will be presented for non point source and sewage treatment plant loads. Recommendations will be provided for cost effective strategies to track future watershed loads and approaches for interfacing watershed water quality contributions with lake wide water quality modelling as an approach for understanding threats and risks to nearshore intakes. *Keywords: Lake Ontario, Pollutant loads, Tributaries, Water quality.*

BOWEN, G.S.[1] and HOWELL, T.[2], [1]Toronto and Region Conservation Authority, 5 Shoreham Drive, Downsview, ON, M3N1S4; [2]Ministry of Environment, 125 Resources Road, Etobicoke, On, M9P 3V6. **Spatial and temporal patterns in E. coli, across the Ajax-Pickering Waterfront of Lake Ontario.**

For the past four years, we have been monitoring water quality and fecal pollution indicators such as E.coli and Enterococcus over onshore-offshore transects across the largely urban waterfront of Lake Ontario adjacent to the communities of Ajax and Pickering. Surveys were undertaken during dry weather and 24 hours after major rain storm events. Samples were also collected in embayment's (Frenchman's Bay), watershed outlets and coastal marshes (Rouge, Duffins and Carruthers). Situated along these transects, are the water intake for the Ajax Drinking Water Treatment Plant, the Duffin Creek Water Pollution Control Plant effluent diffuser and the Pickering Nuclear Generating Station. Distinct onshore - offshore gradients in E.coli counts were observed, with plate counts meeting Ontario recreational swimming objectives usually within 100m of the shoreline. During periods of extended dry warm weather, background levels of E.coli were below method detection. Water temperature, currents and water quality were used to provide insight on transport and dilution of fecal pollution as inferred from levels of E.coli. *Keywords: Pollution sources, Microbiological studies, Coastal processes.*

BOWEN, K.L., JOHANNSSON, O.E., BEDFORD, A., and GERLOFSMA, J., Fisheries and Oceans Canada, 867 Lakeshore Rd., Burlington, ON, L7R 4A6. **Changes in Zooplankton Production and Biomass in the Bay of Quinte, 1975 to 2008.**

Cultural eutrophication has been a concern in Lake Ontario's Bay of Quinte since the early 1970s. Weekly or biweekly zooplankton samples have been collected at 3 stations in the eutrophic upper bay (Belleville - B), mesotrophic middle (Hay Bay - HB), and meso-oligotrophic lower bay (Conway - C) from 1975 to the present. Water depths are 5 m at B, 12 m at C and 32 m at C. The zooplankton community is constantly changing in response to phosphorus control and invasion by new species. Following dreissenid mussel invasion, dry zooplankton biomass averaged 166, 192 and 48 mg.m^{-3} at B, HB, and C, respectively, between 1995 and 2008 (01 May to 06 Oct). The lowest biomass values were from the coldest years, 1992 and 2000. Both zooplankton production and biomass have declined since the post-phosphorus control, pre-dreissenid period of the 1980s and early 1990s. Cladocerans dominate zooplankton biomass, averaging 78% at B, 71% at HB and 55% at C during the 1995-2008 period. Rotifers have been collected since 2000, but their biomass is low compared to that of crustacean zooplankton and veligers. Measured zooplankton lengths in the Bay of Quinte (taken since 1995) were often much lower than mean species dry weights for the Great Lakes. Cladoceran mean lengths were usually <0.5 mm, indicating high rates of planktivory. *Keywords: Zooplankton, Bay of Quinte, Invasive species.*

BOWEN, K.L.[1], JOHANNSSON, O.E.[1], SCHLECHTRIEM, C.[2], GERLOFSMA, J.[1], and ARTS, M.T.[3], [1]Fisheries and Oceans Canada, 867 Lakeshore Rd., Burlington, ON, L7R 4A2; [2]University of Stirling, Stirling, FK9 4LA, Scotland; [3]Environment Canada, 867 Lakeshore Rd., Burlington, ON, L7R 4A6.
Nucleic Acid Ratios and other Growth Indicators in Great Lakes Mysids.

The native opossum shrimp *Mysis diluviana* fills a critical intermediate position in the pelagic food web of the Great Lakes. Mysids have been collected in the spring, summer and fall as part of the Great Lakes Binational Monitoring Program – Ontario in 2003 and 2008, Superior in 2005 and Huron in 2007. Mysid densities are typically lowest in the spring and increase in the summer and fall. Mysid densities at depths <100 m were similar across lakes, but in deeper water, numbers were lowest in Huron. Nucleic acid and protein content are presented as indicators of growth and condition in mysids. For example, total RNA decreases rapidly with starvation. In Huron in 2007, juvenile RNA levels were highest in August, intermediate in October, and lowest in May, when zooplankton was scarcer. There were no consistent differences in mysid RNA levels between 2007 and 2002 in Huron. In August, the station with the lowest mysid RNA (station 138 in 2002) also supported mysid densities over 4 times greater than the other stations sampled. This suggests that even in the summer of 2002, prior to the lower food web collapse, mysids at the highest observed densities may be food-limited and experiencing reduced growth. Further insight may be gained by comparing Huron nucleic acid levels to those in mysids from other lakes. *Keywords: Mysids, Food chains, Indicators.*

BOWERING, T.[1], D'ANDREA, M.[1], DEWEY, R.[2], BISHOP, R.[3], and SNODGRASS, W.J.[4], [1]City of Toronto, Metro Hall, 55 John Street, 18th Floor, Toronto, ON, M5V3C6; [2]City of Toronto, Waterfront Remodeling Consultant, Metro Hall, 55 John Street, 27th Floor, Toronto, ON, M5V 3C6; [3]MMM Group Limited, 100 Commerce Valley Drive West, Thornhill, ON, L3T 1A1; [4]City of Toronto, Metro Hall, 55 John Street, 18th Floor, Toronto, ON, M5V 3C6.

Toronto Wet Weather Flow Management Master Plan : Status of Its implementation and Anticipated receiving water Benefits.

This paper outlines the projects which have been implemented during the first 5 year of the 25 year Master Plan and documents the anticipated benefits toward delisting the associated beneficial use impairments (beach closures, combined sewer overflow control). It evaluates the relative role that source controls (including low impact development practices), conveyance control, and end-of pipe solutions have in achieving these benefits. *Keywords: Impared water use*.

BOWLBY, J.N. and HOYLE, J.A., Ontario Ministry of Natural Resources, R.r. 4, Picton, ONTARIO, K0K 2T0, Canada. **Distribution and Movement of Bay of Quinte Walleye in Eastern Lake Ontario.**

Gillnetting during summer 1992-2008 in the Bay of Quinte and eastern Lake Ontario described the distribution of walleye and prey fish. All age classes of walleye were caught in the Bay of Quinte during April, May, October, and November. During June to September fewer mature walleye were caught in the Bay of Quinte, but dominated the catch outside the Bay. Walleye catches were greater in the eastern basin than central and western basins of Lake Ontario. From 1998 to 2003, we marked 50,948 walleye in the Bay of Quinte and eastern Lake Ontario and tagged 9,161 of them. Anglers and commercial fishermen recaptured 678 tagged walleye and our nets recaptured 1,266 marked walleye. Recaptures indicate mature walleye migrate from the upper Bay of Quinte to the lower Bay and Lake Ontario, peaking in May and continuing into July. Walleye migrate back into the Bay of Quinte starting in September and peaking in October. Mature walleye migrate into Lake Ontario toward less optimum water temperatures and abundant prey, alewife. Summer temperature of Lake Ontario is optimum for walleye growth, and above optimum in the Bay of Quinte. During fall temperature of the Bay of Quinte drops faster than Lake Ontario. Again migration is toward less optimum water temperature and abundant prey, young-of-the-year alewife and gizzard shad. *Keywords: Bay of Quinte, Migration, Walleye, Fish behavior.*

BOYER, G.L. and SATCHWELL, M.F., Department of Chemistry, SUNY-College of Environmental Science and Forestry, Syracuse, NY, 13210. **Good News for Managers: The Cyanobacteria Neurotoxin Beta-Methyl Amino Alanine (BMAA) does not appear to be a major new hazard in the Great Lakes.**

Cyanobacteria produce a wide range of natural toxins. The most recently described cyanobacterial toxin is the amino acid β-N-methyl amino alanine (BMAA). BMAA is a non-protein amino acid produced by a wide range of cyanobacteria (Cox et al., 2005). Originally discovered in cyacad seeds from Guam, it has been associated as a possible cause of amyotrophic lateral sclerosis or Parkinsonism dementia complex. Many potential BMAA-producing genera (e.g. *Microcystis*, *Anabaena*) are common in the Great Lakes. To investigate if BMAA is an emerging threat in Great Lakes ecosystems, voucher samples from more than 1000 samples collected between 2006 and 2009 as part of the NOAA's MERHAB-LGL and OHHI

cyanobacterial toxin monitoring efforts are being retroactively analyzed for BMAA using a highly sensitive HPLC-positive ion electrospray mass spectroscopy method. The detection limit for free BMAA contained within the cells is generally less than 0.01 μg/L of raw lake water. These samples span a wide range of biomass, cyanobacteria species, and many contain one or more known cyanobacterial toxins. However results to date suggest that detectable levels of free BMAA contained within the cells is extremely rare, indicating that this neurotoxin is unlikely to be a major emerging threat to the Great Lakes. *Keywords: Cyanophyta, Harmful algal blooms, Toxic substances.*

BRAVENER, G.A. and MCLAUGHLIN, R.L., 50 Stone Rd. E., Guelph, ON, ON, N1G 2W1, Canada. **Behaviour of Sea Lamprey Approaching Traps on the St. Marys River.**

We used acoustic, radio and integrated transponder (PIT) telemetry, along with underwater video, to examine the behaviour of sea lamprey approaching traps in the St. Marys River. The sea lamprey is an invasive species in the Great Lakes and the target of a bi-national control program. Trapping would provide an important control option if trapping success could be improved. 3-dimensional movement paths were quantified to test whether individuals used common routes to approach trap sites. PIT telemetry and video were used to quantify encounter, entrance and retention rates at study traps, including testing for differences between sex and class of lamprey. Results suggest that individual sea lamprey differ markedly in their movement paths, but generally confine their movements to the boundary layer near the river bottom. Many sea lamprey did not encounter traps, and many did not enter upon encounter, but retention of those that did enter was high. Differences between sex and class of lamprey were negligible. Our findings suggest that trapping success could be improved by adjusting traps in ways that increase the probability of encounter and entrance into traps. *Keywords: Invasive species, Fish behavior, Sea lamprey, Acoustics.*

BRICKER, B.D.[1], DUCKETT, F.[2], HINDE, D.[3], LEINSTER, D.[3], and GIVENS, T.[4], [1]PLAN B Natural Heritage, 176 Fellowes Crescent, Waterdown, ON, L0R2H3; [2]Baird & Associates, 627 Lyons Lane, Suite 200, Oakville, ON, L6J5Z7; [3]The Planning Partnership, 1255 Bay Street, Suite 201, Toronto, ON, M5R2A9; [4]City of Brantford Planning Department, City Hall,100 Wellington Square, P.O. Box 818, Brantford, ON, N3T5R7. **Waterfront Master Planning as a Tool to Protect and Restore River Ecosystems in an Urban Context.**

Waterfront Master Planning in urban areas present an opportunity for scientists and planners to develop outcome based policy direction for the protection and restoration of river ecosystems. A 35 km stretch of the Grand River, a Heritage River, flows through the City of Brantford, and provides important habitat for a diversity of species, including species at risk. The Grand River is also the source of drinking water for the City of Brantford. A multi-disciplinary team is developing a Master Plan framework and policy direction for future land use decision making along the waterfront. Initiatives put forward by the team include: 1) use of bio-swales to polish urban runoff 2) provision of 30 m riparian buffers 3) changes to turf grass management practices in urban parks 4) creation of an urban forestry program to increase tree cover 5) public stewardship and education along a 70 km trail system 6) protection of key natural areas and

groundwater recharge zones 7) use of Stormceptors to polish runoff from older neighborhoods 8) strict controls to mitigate siltation and erosion during land development and 9) performance monitoring. Key to the success of these initiatives will be the formulation of "outcome" based policies to achieve environmental sustainability in a waterfront context. *Keywords: Remediation, Planning, Urban watersheds.*

BRIDGEMAN, T.B.[1], GRUDEN, C.L.[2], CONROY, J.D.[3], KANE, D.D.[4], WINSTON, G.W.[5], CHAFFIN, J.D.[1], PANEK, S.E.[1], and MAYER, C.M.[1], [1]Dept. of Environmental Sciences and Lake Erie Center, University of Toledo, Toledo, OH, 43606; [2]Dept. of Civil Engineering, University of Toledo, Toledo, OH, 43606; [3]Aquatic Ecology Laboratory, The Ohio State University, Columbus, OH, 43212; [4]Division of Natural Sciences and Mathematics, Defiance College, Defiance, OH, 43512; [5]National Center for Water Quality Research, Heidelberg University, Tiffin, OH, 44883. **Lake Erie Algal Source Tracking (LEAST): Contributions of the Maumee River and Lake Sediments to *Microcystis* Blooms.**

The LEAST project was initiated in summer 2009 with several objectives: identifying potential *Microcystis* "seed" populations that initiate summer blooms in western Lake Erie, tracking the biovolume and toxicity of the bloom, and the partitioning of phosphorus into various categories. Coordinated river (5 sites) and lake (6 sites) sampling activities were conducted during 3 periods, pre-bloom (mid-June), early bloom (early August), and late bloom (early September). Only trace *Microcystis* was detected in the river and lake water in June, however sediment from 2 of 6 lake sites contained significant Microcystis (10,000 cells/g wet sediment). On August 6-9, high *Microcystis* counts were obtained sediments at all lake sites and overlying waters (4 of 6 sites), and at 2 of 5 river sites. The visible bloom had decreased by September 9-11 in the water column at all lake sites, but high *Microcystis* counts continued to be obtained from the lake sediments and Maumee River. Microcystin LR was dectected at all river and lake sites, with highest concentrations measured in Maumee Bay during August bloom conditions. *Keywords: Harmful algal blooms, Lake Erie, Microcystis.*

BRIGGS, W.E.[1] and ANDERSON, J.[2], [1]733 Exeter Road, London, On, N6E 1L3; [2]867 Lakeshore Road, Burlington, On, L7R 4A6. **Lake Huron Southeast Shore Working Group - A Multi-stakeholder Effort to Address Nearshore Water Quality Issues.**

The Southeast Shore Area of Lake Huron (Sarnia to Southampton) has seen ongoing issues with respect to beach postings (from pathogens) and algal fouling at various locations along the nearshore which has prompted various complaints from the public and response from various agencies, municipalities and organizations over the past few years. The Southeast Shore Working Group was created in July 2002, in response to these issues under the Lake Huron Bi-national Partnership. The Southeast Shore Working Group is co-chaired by the Ministry of the Environment and Environment Canada and membership includes various federal and provincial government agencies, conservation authorities and local health units. The group is looking at ways to better identify sources of pollution, as well as working at implementing Best Management Practices (BMP) within the region. A Technical Committee of this working group was formed in 2005 to help move forward some of the technical issues that were identified in the

area, with membership including technical resource people from the various groups on the Working Group. This presentation will outline some of the multi-partnered activities that have occurred through this effort and some of the plans for future activities. *Keywords: Watersheds, Multi-stakeholder, Lake Huron, Water quality.*

BROUSSEAU, C.M.[1], RANDALL, R.G.[1], MINNS, C.K.[1], and HOYLE, J.A.[2], [1]Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [2]Ontario Ministry of Natural Resources, 41 Hatchery Lane, Picton, ON, K0K 2T0.
Fish community indices of ecosystem health: Are Index of Biotic Integrity values at Bay of Quinte relatively high compared to other coastal sites in Lake Ontario?

Fish survey data from the Bay of Quinte, together with data from Hamilton Harbour and Severn Sound, were used to develop a Great Lakes Index of Biotic Integrity (Minns et al. 1994) for littoral fish assemblages. Despite being a degraded area (designated as an Area of Concern by the International Joint Commission), the Index of Biotic Integrity (IBI) values were relatively high at the Bay of Quinte. Fish survey data collected since 1988 at the Bay of Quinte and elsewhere indicated that: 1) Quinte IBI scores have remained high and increased at certain locations; 2) IBI values at Quinte were similar to reference sites (in the vicinity but outside the Area of Concern); and 3) IBI and fish catches varied along the Canadian shoreline of Lake Ontario. IBI and fish catch values were correlated with physical and biological attributes at the survey locations, both spatially and temporally. The littoral fish community data confirmed that the Bay of Quinte continues to be a highly productive and diverse ecosystem, and that the Index of Biotic Integrity is a useful index of ecosystem health. *Keywords: Fish, Bay of Quinte, Ecosystem health.*

BROWN, H.C.[1], SHUCHMAN, R.A.[2], and MEADOWS, G.A.[1], [1]University of Michigan: Marine Hydrodynamics Laboratories, 1085 South University Avenue, West Hall, Room 126, Ann Arbor, MI, 48109; [2]Michigan Tech Research Institute, 3600 Green Ct., Ste. 100, Ann Arbor, MI, 48105.
BathyBoat: Autonomous Survey Platform. *Autonomous Environmental Surveys of Nearshore Regions, Lakes, and Rivers.*

This paper reports the design, construction, and testing of a new autonomous surface vessel (ASV) for environmental survey and sampling. The University of Michigan (UMich) as partnered with Michigan Tech. Research Institute (MTRI) to design and fabricate the new ASV "BathyBoat" as a targeted remote sensing platform. The BathyBoat is outfitted with depth sensors, GPS, a high-accuracy digital compass and accelerometer, water temperature and conductivity probes, and other environmental sensors discussed subsequently. An onboard wireless data transmission system offers the ability to monitor, in real-time, the BathyBoat vitals as well as the current sensor readings. In addition, updated mission objectives can be relayed from ship, shore, or aircraft, to the ASV for mid-mission adjustments. Ongoing scientific and engineering research missions are discussed, along with an overview of completed missions in and around the Great Lakes and a summary of field trials on the North Slope of Alaska. *Keywords: Observing systems, Autonomous, Assessments, Boat, Arctic, Surface.*

BROWNSCOMBE, J.W. and FOX, M.G., 1600 West Bank Drive, Peterborough, ON, K9J 7B8. **The Rate of Spread of Round Gobies in the Trent Severn Waterway: Modeling Upstream and Downstream Movements.**

The round goby (Neogobius melanostomus) is an invasive fish found throughout the Great Lakes and is currently expanding its range in the Trent Severn Waterway. Its rate of spread through specific habitat types is not well documented in North American rivers. Thus the objective of this research is to quantify its rate and pattern of spread in the Trent Severn Waterway, and to develop a predictive model for estimating its future distribution. To estimate their density and rate of range expansion, round gobies were angled at sites across the edges of their range in May and August of 2009. Preliminary results indicate very large increases in round goby density at the edges of their range over the summer months, but minimal range expansion over this period. In ideal, rocky habitats at the northern edge of expansion the average goby density increased from 2/m2 in May to 8/m2 in August with a maximum density of 16.5/m2. At the southern edge of expansion, densities increased from 0.5/m2 in May to 3/m2 in August, with a maximum density of 6/m2. It is likely that densities were not yet high enough to motivate individuals to move further up or downstream, and that more rapid expansion will be observed in 2010. *Keywords: Biological invasions, Ecosystem modeling, Fish populations.*

BRUNTON, A.[1], HALEY, D.[2], and DION, K.[2], [1]W.F. Baird & Associates, Oakville, ON; [2]Toronto and Region Conservation Authority, Toronto, ON. **Numerical Models of Hydrodynamics and Sediment Transport as Environmental Assessment Tools for the Don River Mouth Naturalization.**

Part of the planning for the revitalization of the Toronto Waterfront is the naturalization of the mouth of the Don River. Flood protection of the lower Don River is a key component of this project, along with sustainable sediment management throughout the study area. TRCA has identified the lower Don River as the number one priority for flood protection in their jurisdiction. A Class EA was recently completed to provide a solution to flooding west of the Don and this project will be soon under construction. Baird and TRCA are part of the team undertaking the environmental assessment for naturalizing the Don River and addressing flooding in the Port Lands. This presentation presents the analysis of flooding, flood protection performance and sediment transport through numerical modeling of the mouth of the Don using the Delft3-D hydrodynamic and sediment transport model. This includes sediment trap analysis and evaluation of dredging options; assessment of sediment transport and deposition in different naturalized channel alternatives, plus geomorphic analysis, analytical modelling of sediment transport and deposition, and evaluation of the functional design for the restored channel, wetlands and flood spillways. *Keywords: Hydrogeomorphology, Hydrodynamics, Sediment transport.*

BRUSH, J.[1], JOHNSON, T.[2], JAKOBI, N.[2], TARABORELLI, C.[2], and FISK, A.[1], [1]Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, N9V 3Y2; [2]Ontario

Ministry of Natural Resources, Picton, ON, K0K 2T0. **Using Stable Isotopes and Fatty Acids to Understand the Influence of Temperature in Structuring Freshwater Fish Communities.**

Abiotic and biotic resources have the ability to significantly impact ecological communities. In particular, temperature has been recognized to limit the range of species, affect community composition and therefore influence species-interactions. Chemical tracers such as stable isotopes and fatty acids provide relatively new tools to assess feeding relationships in order to delineate species interactions within a food web and feeding preferences at the individual level. This study aims to evaluate the role of temperature on physiologic processes by comparing stable isotope values in wild-caught organisms collected from two areas of contrasting temperature within the Bay of Quinte and eastern Lake Ontario. We expect to observe a decline in δ13C and an increase in δ15N with increasing temperature along the spatial thermal gradient in the Bay of Quinte-Lake Ontario ecosystem,corresponding to an increased physiological demand associated with inhabiting warmer temperature environments. We will evaluate how chemical tracers vary across a temperature gradient and how this influences individual level responses as well as food web structure within an ecosystem. We aim to couple chemical tracer data with traditional metrics to better understand food web relationships and organismal health in large and often complex ecosystems. *Keywords: Stable isotopes, Food chains, Bay of Quinte.*

BRYANT, J.C., BOLISETTI, T., and BALACHANDAR, R., 401 Sunset Avenue, Windsor, ON, N9B 3P4, Canada. **A Case Study on the Impact of the Canard Watershed on the Amherstburg Water Treatment Plant (WTP) Intake Water Quality using Finite Volume Method in FVCOM.**

Computational Fluid Dynamics (CFD) is being used to model hydrodynamics and sediment transport in the Detroit River. The purpose of the study is to determine the impact of the Canard Watershed on the Amherstburg drinking water intake pipe, located approximately 5 kilometres downstream of the Canard River outlet. This research will enable insight into intake protection zone (IPZ) delineation, which is mandated by O. Reg. 287/07 under the Clean Water Act (2006) for all intake pipes in the Great Lakes and Great Lake connecting channels. Finite Volume Method is being used in FVCOM to model the hydrodynamics of the Detroit River. The computational domain extends from the connection of Lake St. Claire and the Detroit River until Lake Erie. The water surface is divided into approximately 6500 triangular shaped elements with sides ranging from 300 m down to 100 m. The vertical domain is divided into equal layers using a terrain following sigma-coordinate transformation. Flow and surface elevation are used as the inlet and outlet boundary conditions for the Detroit River, respectively, with zero seepage along the walls and bed. Canard watershed sediment loadings are injected into a tracer control element, where the sediment transport is determined by continuity and momentum transport governing equations. *Keywords: Detroit River, Hydrodynamic model, Sediment transport.*

BUMSTEAD, N.L. and LONGSTAFFE, F.J., University of Western Ontario, London, ON, N6A 5B7. **The Stable Isotope Paleolimnology of Lake Simcoe.**

This study examines variations in lake water sources and productivity within the Lake Simcoe Basin during the last 10,000 years using the oxygen- and carbon-isotope compositions of ostracodes. During the retreat of the Laurentide Ice Sheet there was a minimum of two significant meltwater inputs into the basin – as signaled by negative shifts of ~10 ‰ in the oxygen-isotope compositions of ostracodes from sediment cores. Periods of more positive oxygen-isotope compositions reflect a basin dominated by water originating in the local/regional watershed or, possibly, from overflow of ^{18}O-enriched surface waters from a stratified Lake Agassiz. The changes in oxygen-isotope composition coincide with shifts in ostracode populations. *Candona subtriangulata* thrived during periods of meltwater influx characterized by very low δ18O values while *Candona rawsoni, Fabaeformiscandona caudata* and/or *Cytherissa lacustris* flourished during periods of limited low-^{18}O meltwater input, during which time lakewater δ18O values were much higher. The periods largely free of low-^{18}O meltwater influx are also characterized by a ~2 to 3 ‰ decrease in ostracode δ13C values. This difference likely arises from elevated levels of decay and respiration within the lake. *Keywords: Lake Simcoe, Stable isotopes, Oxygen.*

BURLAKOVA, L.E.[1], KARATAYEV, A.Y.[1], PENNUTO, C.[1], MASTITSKY, S.E.[1], HAJDUK, M.M.[1], BASILIKO, C.P.[1], and CONROY, J.[2], [1]Great Lakes Center, Buffalo State College, 1300 Elmwood Avenue, Buffalo, NY, 14222; [2]Department of Evolution, Ecology, and Organismal Biology, Ohio State University, Columbus, OH, 43212.
Dominance Of Exotic Invertebrates Changes The Structure Of The Lake Erie Benthic Community.

To estimate the role of exotic species in the benthic community of Lake Erie, we collected samples from all lake basins in the summer of 2009, and compared these data to a 1979 survey (Dermott 1994). In 1979, 3 exotic species (Gastropoda: Bithynia tentaculata, and Oligochaeta: Branchiura sowerbyi, Potamothrix vejdovskyi) constituted < 2% of the total benthic density and biomass. The 1979 community was dominated (density) by oligochaetes, the mollusc Pisidium and the amphipod Diporeia, while chironomids, oligochaetes, Sphaerium, Diporeia, and Pisidium dominated in terms of biomass. Eight exotics were found 30 yrs later, including molluscs Dreissena r. bugensis, D. polymorpha, Sphaerium corneum, Cipangopaludina chinensis, Potamopyrgus antipodarum, Valvata piscinalis, the oligochaete B. sowerbyi, amphipod Echinogammarus ischnus, and numerous shells of B. tentaculata. Exotics were disproportionally abundant among molluscs, and were absent from the most diverse group of native invertebrates - insects. Benthic invaders now constitute 40% of total benthic density, and over 95% of the total wet mass. Benthic community structure and dominance has changed significantly since 1979, and the community is currently dominated by exotic species. *Keywords: Exotic species, Community, Benthos, Lake Erie.*

BURNISTON, D.A., Canada Center for Inland Waters, 867 Lakeshore Rd., Burlington, ON, L7R 4A6.
Contaminants in Hamilton Harbour Water.

During the 2008 and 2009 field season, WQM&S conducted extensive water quality monitoring in Hamilton Harbour to determine ambient contaminant levels in the water column, and in support of the proposed Randle Reef remediation project. Polycyclic Aromatic

Hydrocarbon (PAH) and metal concentrations for monthly whole water samples were determined at 9 sites in the Harbour. Ambient background PAH levels were roughly 30 ng/L, while the Randle Reef and Windermere arm sites were typically 60 and 200 ng/L, respectively. Levels of copper were consistently above the CCME guidelines; background levels in the Harbour were only slightly lower than concentrations found at Randle Reef, with Windermere arm samples generally the highest. Concentrations of PCBs were determined in both dissolved and particulate phases at ten sites in the harbour to investigate partitioning between the two phases. The whole (combined phase) water ambient background concentrations were typically 2 ng/L, which included the Randle Reef sites. PCB concentrations at Windermere arm sites averaged 15 ng/L; the highest levels of PCBs were associated with boat slips along the highly industrialized southern shoreline of the harbour. *Keywords: PCBs, Environmental contaminants, PAHs.*

CALABRO, E.J., MURRY, B.A., UZARSKI, D.G., CLEMENT, T.A., and WOOLNOUGH, D.A., Department of Biology Central Michigan University, Brooks 156, Mt. Pleasant, MI, 48858.
Applying Great Lakes Coastal Wetlands Indices of Biotic Integrity to Inland Lakes of Beaver Island.

Biological indicators or indices of biotic integrity (IBI) have been developed for some systems for land management and regulatory agencies to categorize the level of degradation of a given ecosystem. IBIs are most often used in lotic systems and those IBIs that can be used over wide geographic regions and/or many system types are deemed most valuable. Lacustrine system's intrinsic complexity and multidimensionality greatly affects the transferability of particular indices created for certain lakes. The robustness and transferability of IBIs created for macroinvertebrates and fish (Uzarski et al. in 2004, 2005) for fringing, lacustrine marshes of the Great Lakes are currently being tested on the inland lakes of Beaver Island, Lake Michigan. In contrast to many other IBIs that tend to be system specific, Uzarski et al.'s (2004, 2005) IBIs should be transferable since they assess food web structure and are therefore, not dependant on a specific species pool. The transferability of both IBIs is probable; however species richness is a component that may need to be redefined for the lower diversity found in the inland lakes when compared to the Great Lakes. The transferability of both IBIs will be determined by relating rescaled scores with an established disturbance gradient. *Keywords: Bioindicators, Water quality, Wetlands.*

CALDWELL, T.J. and WILHELM, F.M., The University of Idaho, Dept. of Fish and Wildlife Resources, CNR Room 105 P.O. Box 441136, Moscow, ID, 83844.
The role of the opossum shrimp (*Mysis relicta*) in the nutrient and zooplankton community dynamics of a large and deep (>350 m) oligotrophic lake in Northern Idaho, USA.

In general, *Mysis* introduced into Pacific Northwest lakes in the 1960's disrupted lake food webs because of competition with fish fry for zooplankton prey. Additionally, mysids may remove nutrients from surface waters via diel vertical migration (DVM) thus limiting lake productivity. Lake Pend Oreille (LPO) is a large (38,000ha) and deep (351m) oligotrophic lake. We hypothesized and tested that; i) mysids represent a net sink of nutrients from the surface to

the deep water via DVM in LPO due to its depth; and ii) that mysids compete with fish for zooplankton prey. We measured phosphorous (P) release by mysids during stages of DVM and compared their gut contents to the natural zooplankton assemblage at two widely separated sites. Release rates between ascending and descending phases of DVM were similar (0.66 ±0.13, and 0.58±0.14 μg P/hr/ind), respectively, for the North site, and (0.73±0.17, and 0.63± 0.13 μg P/hr/ind), respectively, for the South site. Analysis of gut contents showed consumption of cladocerans, copepods, diatoms, algae and unidentifiable matter. Our results suggest that mysids do not represent a net loss of nutrients from surface waters in LPO. However, consumption and reduction of zooplankton by mysids could negatively affect fish production. *Keywords: Invasive species, Mysids, Nutrients, Zooplankton.*

CALVERT, M.B. and MCCARTHY, F.M.G., Earth Sciences, Brock Univeristy, 500 Glenridge Ave., St. Catharines, ON, L2S 3A1. **When Nanabush wept: Paleodrought-forced early Holocene lowstands, and implications under projected climatic scenarios.**

Early Holocene closed basin lowstands (e.g. Lake Hough, Lake Stanley, Early Lake Erie) identified in the North American Great Lakes can be explained by paleodrought conditions. The existence of brackish water in Lake Hough, for instance, is recorded by microfossils and in the oral traditions of the Ojibway, but this paleodrought event has not been well-characterised. Transfer function analysis of pollen records from several dozen small lakes in the Great Lakes watershed provides numerical estimates of past climate (July temperature, January temperature and mean annual precipitation). A statistical model of the hydrological response to the early Holocene drought was developed and refined by comparing the climate reconstructions with geological evidence of lowstand conditions in the basins of all five Great Lakes. The major changes in lake level and water quality that resulted from relatively minor changes in climate draw attention to possible declines of the Great Lakes under future climate scenarios. *Keywords: Paleolimnology, Hydrologic budget, Climate change.*

CAMPBELL, L.M.[1], ARCAGNI, M.[2], REVENGA, J.[2], RIBEIRO GUEVARA, S.[2], and ARRIBÉRE, M.A.[2], [1]School of Environmental Studies, Queen's University, Kingston, ON, K7L 3N6; [2]Laboratorio de Análisis por Activación Neutrónica, Centro Atómico Bariloche, San Carlos de Bariloche, Argentina. **Bioaccumulation and transfer of mercury and silver in an ultraoligotrophic lake, Patagonia, Argentina.**

Total mercury and silver concentrations and nitrogen stable isotope ratios (delta-15N) were measured in fish muscle and liver, plankton, benthic macroinvertebrates and macrophytes in Lake Moreno, an ultraoligotrophic deep lake adjoining one of Argentina´s largest lakes, Lake Nahuel Huapi, northwest Patagonia. The delta-15N signature increased with trophic level from producers to primary, secondary consumers and fish. The log transformed concentration of THg from all the organisms in the food web regressed against delta-15N was not significant (p=0.09). On the other hand, silver behaved differently with significant Ag biodilution between phytoplankton and zooplankton in the pelagic samples. However, when whole biota from littoral areas and fish were analysed, significant Ag biomagnification was observed for the whole food web. Both Ag biodilution and biomagnification operates simultaneously in Lake Moreno, while

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Hg unexpectedly did not demonstrate significant biomagnification trends. *Keywords: Stable isotopes, Food chains, Bioaccumulation.*

CARDOSO, L.S.[1], MOTTA MARQUES, D.M.L.[2], FRAGOSO JR, C.R.[2], and BECKER, V.[2], [1]Universidade Federal do Rio Grande do Sul / Instituto de Biociências, Porto Alegre, RS, 91501-970, Brazil; [2]Universidade Federal do Rio Grande do Sul / Instituto de Pesquisas Hidráulicas, Porto Alegre, RS, 91501-970, Brazil. **Hydrodynamics-driven biological processes in two subtropical lakes.**

Hydrodynamic processes and biological changes occurred over different spatial and temporal scales in two large and long subtropical lakes. In Itapeva Lake, water level and water velocity induced short-term spatial gradients, while wind action (namely, turbidity, suspended solids, and water level) was most strongly correlated with the seasonal spatial gradient. Diatoms and protists were the indicator groups for hydrodynamic, with instant responses in spatial distribution. The rate of change in the phytoplankton was very high indicating the occurrence of intense, rapid environmental changes, mainly in spring. In Mangueira Lake, wind driven hydrodynamics creates zones with particular water dynamics. Velocity and direction of fluxes, and water level were changed quickly. Depending on factors such as fetch and wind, areas dominated by down and upwelling could be identified in deepest parts. The result was a distinct patchiness on phytoplankton and zooplankton. In general, the simulated chlorophyll-a concentration increased from the littoral to the pelagic zones. We also found a stronger grazing pressure by zooplankton in the littoral zones, indicating a top-down control on phytoplankton there. Our simulation indicated also a more extensive submerged macrophyte bed in the south littoral zone, probably due to the dominant NE wind. *Keywords: Hydrodynamic model, Subtropical lake, Plankton, Water level fluctuations.*

CARLSON MAZUR, M.L.[1], WILCOX, D.A.[2], and WILEY, M.J.[3], [1]USGS - Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105; [2]SUNY -The College at Brockport, 350 New Campus Drive, Brockport, NY, 14420; [3]University of Michigan, 440 Church Street, Ann Arbor, MI, 48109. **Water-balance interactions of plants and groundwater in a Lake Huron coastal wetland complex.**

Coastal wetland habitat of the Great Lakes likely will experience dramatic changes over time due to climate change and related stressors. Because trajectories of vegetation change in wetlands are intricately tied to the water balance, ecosystem response will depend, in large part, on the interactions between groundwater fluxes and evapotranspiration through their respective influences on the water table. The specific dynamics, however, are not well-defined. To this end, we investigated the water-balance dynamics of a Great Lakes wetland complex consisting of relict beach ridges and intervening swales to explore how variation in swale hydrology arises through interactions between plants and site hydrogeology and how inter-annual climatic variability affects these interactions. The results of this study suggest that underlying geology plays an integral role, but the influence of some plant communities may be equally important. Nonetheless, if precipitation in the Great Lakes is reduced over the growing season, groundwater likely will buffer climate-change effects in wetlands by slowing vegetation change associated

with long-term soil drying. This study provides a clearer representation of the present-day interactions to help inform our understanding of climate-change effects in wetlands. *Keywords: Coastal wetlands, Groundwater, Hydrologic cycle, Water table, Climate change, Ecohydrology.*

CARRICK, H.J.[1], BOURBONNIERE, R.A.[2], BULLERJAHN, G.S.[3], DESOUZA, N.A.[3], MCKAY, R.M.L.[3], SAXTON, M.A.[4], SMITH, R.E.H.[5], TWISS, M.R.[6], and WILHELM, S.W.[4], [1]School of Forest Resources, Pennsylvania State University, University Park, PA, 16802; [2]Environment Canada, Canadian Centre for Inland Waters, Burlington, ON; [3]Department of Biological Sciences, Bowling Green State University, Bowling Green, OH; [4]Department of Microbiology, University of Tennessee, Knoxville, TN; [5]Department of Biology, University of Waterloo, Waterloo, ON; [6]Department of Biology, Clarkston University, Potsdam, NY.
 Plankton on Ice: Taxonomic Composition, Production, and Grazing Loss of Winter Assemblages in Lake Erie.

Comparatively few winter observations are made for lakes residing in the temperate zone, despite the relatively long duration of this season. As such, we hypothesize that the abundance and production of winter microbial assemblages are comparable to those present in the summer. To test this hypothesis, water samples were collected at 5 offshore stations along an west-east transect in Lake Erie. The range in phytoplankton abundance observed here was comparable to that measured during the summer (range 20-150 ugC/L), and biomass decreased from west to east. Diatoms, cryptophytes and picocyanobacteria dominated the assemblage. Levels of primary production were appreciable at the five stations, and ranged from 0.4 to 11 ug C/L/h. These values corresponded well with those measured on summer assemblages incubated at low irradiance (<80 uEinst/m2/s). Picocyanobacterial growth and loss rates decreased along the west to east gradient in the lake. The absolute growth rates were relatively high at three stations in the lake (turnover rates ranging from <1 day to 2 days), and were indicative of assemblages that were physiologically active. Collectively, these data indicate that winter phytoplankton biomass was large, and exhibited production rates comparable to those measured for summer assemblages in Lake Erie. *Keywords: Climate change, Winter, Plankton, Productivity.*

CHAFFIN, J.D., BRIDGEMAN, T.B., HECKATHORN, S.A., and MISHRA, S., Dept. of Environmental Sciences and Lake Erie Center, University of Toledo, Toledo, OH.
 Western Lake Erie *Microcystis* Nutrient Deficiencies in the Large Bloom of 2008.

Microcystis blooms in western Lake Erie are supported by high nutrient (nitrogen, N; phosphorus, P) concentrations. To determine if N, P, or micronutrients were limiting growth, we collected *Microcystis* during 2008 for analysis of cellular nutrient content. Soluble nutrient concentrations were also measured over the entire summer. N content of *Microcystis* remained high over the summer, despite very low nitrate concentrations and low total N to total P ratio in the lake during late summer. Ammonium was constant spatially and over the summer, and likely provided the N source for *Microcystis*. P content suggested *Microcystis* was P limited, but not extremely deficient. Offshore *Microcystis* P content was similar to that of the near shore despite soluble P concentrations of offshore waters that were three-fold less than the bay. This indicates

the potential of luxury uptake of P in Maumee Bay may support offshore growth. *Microcystis* was also analyzed for content of micronutrients. Iron and magnesium decreased as P content decreased. All other nutrients had ranges typical for phytoplankton, except nickel, which was 6 times above typical. These results suggest P limits *Microcystis*, but micronutrients also have impacts on bloom cellular health in western Lake Erie. *Keywords: Microcystis, Lake Erie, Nutrients.*

CHALONER, D.T.[1], JANETSKI, D.J.[1], MOERKE, A.H.[2], and LAMBERTI, G.A.[1], [1]Department of Biological Sciences, University of Notre Dame, Notre Dame, IN, 46556; [2]Department of Biological Sciences, Lake Superior State University, Sault Ste. Marie, MI, 49783. **Ecological Effects of Pacific Salmon Spawners on Great Lakes Stream Ecosystems.**

Pacific salmon (*Oncorhynchus* spp.) are an important Great Lakes resource, but little is known of their ecological effects in streams where they spawn. We evaluated four mechanisms by which salmon spawners influence Great Lakes streams: nutrient enrichment, substrate disturbance, contaminant transport, and competition with native salmonids. Water chemistry and biotic responses to salmon runs were studied in Lake Michigan and Superior tributaries. Results showed dissolved nutrient concentrations can increase during salmon runs, but the extent can reflect ambient concentrations and is not always related to spawner densities. Disturbance effects on benthic algae and macroinvertebrates were also variable, with strongest impacts occurring in streams with highest spawner densities and smallest sediments. Polychlorinated biphenyl concentrations were 2 to 60 times higher in resident fish from sites with salmon spawners than those from control sites. Daily long-distance (>200 m) movements of brook trout (*Salvelinus fontinalis*) increased 10-fold after salmon arrived, suggesting displacement. Our results suggest that Pacific salmon can have multiple impacts on Great Lakes streams that can be strongly influenced by environmental conditions. Great Lakes salmon management should consider potential effects on native stream biota. *Keywords: Pollutants, Ecosystem engineer, Salmon, Fisheries, Ecosystems, Resource subsidy.*

CHANDLER, D.J. and HEATH, R.T., Dept. Biological Sciences, Kent State University, Kent, OH, 44242. **Evidence of N and P Co-Limitation of Phytoplankton Growth in the Central Basin of Lake Erie, Summer 2008.**

For the past decade we and others have observed a decline in physiological indicators of phytoplankton P-limitation. We have observed an increase in Phosphate Turnover Time (PTT) and Phosphorus Deficiency Index (PDI), and a decrease in Specific activity of Alkaline Phosphatase (APA) and Phosphorus Debt (P-Debt)at sites throughout Lake Erie. Each of these physiological characteristics indicates that phytoplankton may not be strongly growth limited by P-availability. In Schelske-style factorial nutrient amendment experiments in which N (ammonium chloride) and P (monobasic sodium phosphate) factorially amended samples drawn from selected sites in the Central Basin of Lake Erie and from Sandusky Bay in July to early September 2008. We found that neither P-amendments alone nor N-amendments alone stimulated phytoplankton growth following 7 days incubation (150 $\mu E\ m^{-2}\ s^{-1}$; 16h L: 8h D) at 24°C. In contrast, we observed that growth over that time (measured as increase in chl *a*)

significantly increased when replicate samples were amended with both N and P. Greatest stimulation of growth occurred when the total (ambient + amendment) N:P was 10 − 18. These findings indicate that phytoplankton in those assemblages examined were co-limited by availability of both N and P. *Keywords: Biogeochemistry, Phytoplankton growth, Lake Erie, Nutrients.*

CHAPRA, S.C.[1], BRADLEY, L.[2], BACKUS, S.[2], and DOLAN, D.M.[3], [1]Civil and Environmental Engineering, Tufts University, Medford, MA, 2155, US; [2]Water Quality Monitoring & Surveillance Division, Environment Canada, Burlington, ON, L7R 4A6, Canada; [3]Natural and Applied Sciences (Math), University of Wisconsin-Green Bay, Green Bay, WI, 54311, US. **Temporal and Spatial Trends of Great Lakes Precipitation Chemistry.**

Data collected over the past 30 years are compiled and analyzed to identify trends in the chemistry of precipitation in the Great Lakes region. Measurements are drawn from the National Atmospheric Deposition Program (NADP) for 1979-2008 and the Great Lakes Precipitation Network (GLPN) for 1994-2009. Concentration time series are developed for several key variables including total phosphorus, nitrate, ammonia, sulfate, chloride, pH and specific conductance. In addition, annual loading time series to the Great Lakes are estimated for total phosphorus, nitrate and chloride. Spatial isopleths plots and interstation comparisons are used to assess spatial patterns. The results indicate declines in several constituents. In particular, sulfate, nitrate and chloride levels appear to have declined since the early 1980s. *Keywords: Atmosphere-lake interaction, Loadings, Mass balance, Nutrients, Deposition, Ions.*

CHARLTON, M.N., 218 Fifth Concession E, Rural Route #1, Waterdown, ON, L0R2H1. **Prioritization: Are There Any Givens?**

Out of the thousands of potential restoration projects are there any that shouldn't be done? Are there any that are obviously high priority? Support of existing programs to clean up contaminated sediment and maintain LaMP activities and implementation would seem to be high priority. For non-point sources of nutrients large problem areas such as the Maumee River would be important but are programs designed to discover whether there have been any fundamental errors in land use given long-term experience? Quick results from non-point projects may not be apparent and some degree of faith in their eventual efficacy may be required. At the same time, effluent standards for sewage plants that were advanced forty years ago are now mediocre. Public support and accountability would seem to be important factors as well as the breadth and depth of restoration. *Keywords: Risk assessment, Restoration, Water quality, Environmental policy.*

CHENG, P. and AUSTIN, J.A., Large Lakes Observatory, University of Minnesota, Duluth, Duluth, MN, 55812, USA. **The role of ice cover in the response of thermal structure to warming climate: a numerical study of Lake Superior.**

Air temperatures around the globe have increased significantly during the past decades. Corresponding to the warming climate, observations showed that summer water temperatures have increased rapidly in the Lake Superior, and the ice cover was assumed to be a primary factor in controlling the thermal interaction between the lake and the atmosphere. Using a coupled ice-lake model, we carried out numerical simulations of Lake Superior with realistic meteorological forcing in 2008. The model was validated using observations at several mooring stations in the lake. Modeled ice cover, vertical temperature structure and heat content are consistent with observations. The model, was run with the same forcing of 2008 and warmer air temperatures at an increasing rate of 0.1 degree/yr.Tthe long-term simulation showed that under the warming climate ice cover index decreased and the surface water temperatures increased significantly during the summer season with a increment four times than that of the winter season. The averaged summer surface water temperatures were increasing at a rate of 0.08 degree/yr in the early period, and at a rate of 0.07 degree/yr at the later period, indicating that with ice formation the surface water temperature of the lake responds to warming climate faster than it in the absence of ice. *Keywords: Ice, Hydrodynamic model, Lake Superior.*

CHENG, S.T. and WILEY, M.J., School of Natural Resources & Environment, University of Michigan, Ann Arbor, MI, 48109, US. **Climate Change: Warming up Muskegon River and its Chinook Salmon Community.**

Climate change has become a serious issue globally. To explore long-term, large-scale hydrological, thermal, and biological impacts associated with climate change, we applied the Reduced Parameter Stream Temperature Model linked to an existing watershed multi-model, the Muskegon River Ecological Modeling System. Predictions from the 4th IPCC A1B Scenario were used to drive the entire integrated modeling system. Modeling suggested that the Muskegon River will experience 2~4.5oC warming in monthly water temperature. The greatest increases in water temperature will occur in spring and warm years. Moreover, groundwater fed tributaries will experience greater water temperature changes than large channels/reservoirs in winter. However, this spacial distinction will be less typical in summer. Results also indicated that changes in water temperature significantly alter the timing of Chinook salmon early life history. According to the 10-year averaged prediction, warming climate can cause early season spawning to be delayed about 2 weeks, and late season one to be delayed about one month. In addition, our models predicted that fry emergence would on average occur one month earlier due to warming climate. This integrated modeling approach should be useful to fishery managers interested in planning adaptations to cope with climate change. *Keywords: Water temperature, Modeling, Chinook salmon, Climate change.*

CHESSIE, P.[1], LIN, G.[2], and SNODGRASS, W.J.[2], [1]City of Toronto, Metro Hall, 55 John Street, 18th Floor, Toronto, ON, M5V3C6; [2]City of Toronto, Metro Hall, 55 John Street, 18th Floor, Toronto, ON, M5V 3C6. **A Climate Change Adapation Strategy To Address Urban Flooding and delisting the Toronto AOC: A City Of Toronto Perspective.**

This paper presents an evaluation of the wide spread surface and basement flooding as a result of extreme storm events, which exceed the existing urban system's storm drainage design

capacity, especially the August 19, 2005 storm, which exceeded 1 in 100 year return frequency, A comprehensive engineering review of chronic basement flooding areas, in the City of Toronto, has shown that, with the lack of a major storm drainage system, the roads do not typically provide a continuous flow route, are very flat or have low lying areas with no place for the stormwater to outlet. In these areas, stormwater enters the sanitary sewer system from a number of sources, leading to the surcharging of the sanitary sewer system and consequently basement flooding. IN addition, system improvement works in the past have been insufficient to guard against larger more intense rainfall events. An adaptive management strategy to help guard against future incidences of basement flooding during extreme storm events has been developed, using an integrated (storm and sanitary sewer) systems approach, which includes: source (lot level) controls; minor system (storm sewer) improvements; sanitary sewer system improvements; and major system (overland flow) control.

CHIANDET, A.S. and SHERMAN, R.K., Severn Sound Environmental Association, 67 Fourth Street, Midland, ON, L4R 3S9, Canada. **Metalimnetic Oxygen Minimum and Algal Associations in an Isolated Bay of Honey Harbour, Georgian Bay.**

Due to limited water exchange with the open waters of Severn Sound, North Bay, an isolated bay near Honey Harbour, experiences metalimnetic and hypolimnetic oxygen depletion each summer. We investigate trends in volume-weighted hypolimnetic oxygen (VWHO) and areal hypolimnetic oxygen depletion (AHOD), as well as algal associations with the metalimnetic minima in oxygen concentration profiles. VWHO ranged from 1-3 mg/L, with no trends in 7 sampling years over a 28 year period. AHOD ranged from 15-57 $mg/cm^2/d$, and increased slightly over the study period. By late summer, oxygen minima consistently developed within the metalimnion at 7-8 m depth, with minimum oxygen concentrations declining to 0.4-2.9 mg/L each sample year, with bottom water (18 m) concentrations declining to 0.1-1.2 mg/L. Temperatures within these depth zones are suitable for coldwater fish, however the lack of oxygen restricts available habitat within the water column. In 2009, biweekly algae profiles were taken using a FluoroProbe. Results from these phytoplankton profiles suggest dominance of cryptophytes and diatoms. Depth specific sampling within the metalimnion should be done to precisely identify the factors responsible for these minima. *Keywords: Oxygen, Phytoplankton, Trophic level.*

CHILDRESS, E.S., MCINTYRE, P.B., and ALLAN, J.D., University of Michigan School of Natural Resources and Environment, 440 Church St., Ann Arbor, MI, 48109. **Incorporation of Nutrients from Sucker Migrations into Great Lakes Tributary Food Webs.**

Catostomid fishes migrate in huge numbers out of the Great Lakes into tributaries to spawn, potentially supplementing the supply of carbon and nitrogen to riverine food webs. These fish have enriched nitrogen isotope ratios compared to tributary food webs, enabling isotopic tracking of nutrient subsidies delivered by the migrations. In addition, sucker migrations differ in size among tributaries and in extent of upstream penetration due to barriers. In this study the N isotope ratios of *Limnephilus* caddisflies were tracked in enclosures with and without fish carcasses. Additionally isotopic ratios of *Limnephilus* were tracked over the course of a

spawning migration upstream and downstream of an experimental barrier to migrations in a nutrient-poor stream. Caddisflies rapidly incorporated fish-derived N in both enclosures and field conditions. Spawning catostomids represent an important seasonal nutrient source for stream food webs. Obstruction of breeding migrations of suckers and other native fishes by dams and other anthropogenic barriers is likely to have significantly altered ecosystem processes in Great Lakes tributaries. *Keywords: Stable isotopes, Nutrients, Food webs, Migrations.*

CHITTIBABU, P., YERUBANDI, R., and ZHANG, W., Aquatic Ecosystem Management Research Division (AEMRD), Water Science and Technology Directorate, Environment Canada, 867 Lakeshore Rd., Burlington, ON, L7R4A6. **Modelling of Circulation in Lake of the Woods.**

A high resolution unstructured grid two dimensional finite element model (ADCIRC) was applied to simulate the water levels and circulation patterns in Lake of the Woods during the summer of 2007. A unstructured grid facilitated to represent the complex geometry of Lake of the Woods. The model mesh contains a total of 23658 elements. The model was forced with water surface elevations at Rainy river inlet , south of Lake of the Woods and at Keewatin , north of lake of Woods and a time varying spatially uniform wind field generated has been used. The model was validated with the available water levels at several stations. The model was able to capture the circulation pattern in the lake reasonably well. Model results are analysed to characterize the seiches and inter-basin transports in the basin. *Keywords: Seiches, Lake model, ADCIRC, Hydrodynamic model, Water level fluctuations.*

CHRISTIE, G.C. and SIEFKES, M.J., Great Lakes Fishery Commission, 2100 Commonwealth Blvd., Ann Arbor, MI, 48176. **Killing Sea Lampreys to Protect Lake Sturgeon in the Great Lakes.**

Application of pesticides, called lampricides, to streams has resulted in effective suppression of sea lampreys in the Laurentian Great Lakes. The suppression of these parasitic, invasive fish from the Atlantic Ocean, protects many native fish in the lakes. Much research has focused on the selectivity of lampricides and on techniques for applying them that reduce the collateral mortality of other fish in streams throughout the half century of sea lamprey control. Lake sturgeon populations in the Great Lakes are listed or under consideration for listing in all jurisdictions including recently designation as threatened under Ontario's Endangered Species Act. Like lampreys, sturgeon are primitive fish and are more sensitive to lampricides than other teleosts. Efforts to modify lampricide concentrations to protect lake sturgeon allow more sea lampreys to survive and escape to the lakes where they kill more fish, including lake sturgeon. The negative effect of increased mortality of adult lake sturgeon from sea lampreys in the lakes outweighs the effects of the limited mortality of larval lake sturgeon that may occur during intermittent treatments of streams. Sea lamprey control benefits efforts to restore lake sturgeon by protecting adult lake sturgeon in the Great Lakes. *Keywords: Sea lamprey, Lake sturgeon, Invasive species, Endangered species, Fish management.*

CHRISTIE, G.C.[1], CRAWFORD, S.S.[2], BOCKING, S.A.[3], WHILLANS, T.H.[3], and GADEN, M.E.[1], [1]Great Lakes Fishery Commission, Ann Arbor, MI; [2]University of Guelph, Guelph, ON; [3]Trent University, Peterborough, ON. **Toward an Ecosystem Approach to Fisheries Management – Henry Regier's Influence on the Great Lakes and Beyond.**

With challenging science and catalytic energy, Henry Regier has played a central role in the application of an ecosystem approach to fisheries science in the Great Lakes and around the world. Our understanding of stress-response in aquatic systems emerged in his early Great Lakes fisheries work. The framework from his doctoral research comparing fish ponds formed the basis for a comparative ecosystem approach that emerged in the Salmonid Communities in Oligotrophic Lakes (SCOL) Symposium in 1971 and has continued to be a foundation for evaluating systems responses to human action. From his work, fisheries science on the Great Lakes and in Ontario emerged from perceptions of closed, linear and deterministic elements that could be described with mathematical equations to new understanding of open, non-linear, and self-organizing systems. This systems approach continues to evolve in fisheries science extending from its origins with Henry and his colleagues on the Great Lakes to marine systems today. Committed to the human dimension of fisheries management, Henry's work with institutions at all scales shaped governance of the Great Lakes. We will examine the effects of this ecosystem approach on successes in fisheries restoration on the Great Lakes and consider the direction Henry's work points for future challenges.

CIBOROWSKI, J.J.[1], BARKER, N.[1], and SHERMAN, R.K.[2], [1]Department of Biological Sciences, University of Windsor, Windsor, ON, N9B 3P4; [2]2Severn Sound Environmental Association, 67 Fourth St, Midland, ON, L4R 3S9. **Benthic Invertebrate Community Composition in Severn Sound, (Georgian Bay) Lake Huron – 2008.**

Severn Sound was designated an Area of Concern 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 previously sampled in 1994 and 1998) in Midland Bay, Penetang Bay and adjacent open waters in April & August 2007 and August 2008. In 1998, 34 *Hexagenia* larvae/m^2, 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, naidid 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: Eutrophication, Georgian Bay, Benthos.*

CLARAMUNT, R.M.[1], BARTON, N.T.[2], FITZSIMONS, J.D.[3], and GALAROWICZ, T.L.[2], [1]96 Grant Street, Michigan Department of Natural Resources, Charlevoix, MI, 49720; [2]146 Brooks

Hall, Central Michigan University, Mount Pleasant, MI, 48859; [3]867 Lakeshore Road, Dept. of Fisheries and Oceans, Burlington, ON, L7R 4A6. **Microhabitat Association of Hemimysis on Fish Spawning Reefs in Northern Lake Michigan.**

Starting in 2006, the bloody-red mysis (Hemimysis anomala) was discovered as a new invasive species in the Great Lakes, specifically found in the Muskegon channel which flows into Lake Michigan. As predicted at the time of introduction, the bloody-red mysis has expanded its range in Lake Michigan as we have recently documented them in Grand Traverse Bay. Using a gear designed to sample lake trout and lake whitefish eggs during spawning, we found variable densities of bloody-red mysis within interstitial spaces of substrate particles across three nearshore reefs at Elk Rapids, Lake Michigan. The highest densities of bloody-red mysis were found at the reef with the highest quality fish spawning habitat defined as rounded cobble/rubble with the greatest amount of interstitial spaces, reef depth, and currents. Based on the association of bloody-red mysis with these habitat characteristics and the predominance of this type of spawning habitat in north-eastern Lake Michigan, we predict substantial expansion of bloody-red shrimp in this area. Additional evaluation is needed to determine the potential interactions with early life stages of native fishes. *Keywords: Exotic species, Hemimysis, Biological invasions, Reef, Habitats, Grand Traverse Bay.*

CLARK, M.G., MCGOLDRICK, D.J., KEIR, M.J., and BACKUS, S.M., Water Science and Technology Directorate, Environment Canada, 867 Lakeshore Road. P.O. Box 5050, Burlington, ON, L7R 4A6. **Organochlorine Pesticides in Whole Fish Tissues, in the Canadian Waters of the Great Lakes: 1977 to 2008.**

In 1977, the Government of Canada initiated the Fish Contaminants Monitoring and Surveillance Program (FCSP) to monitor various environmental contaminants, including concentrations of organochlorine pesticides (OC's), such as DDT, mirex, and chlordane. In the 1950's, OC pesticides became widely used in agriculture and for disease vector control. Bans and restrictions pertaining to their use were put in place in the 1970's; however, OC's persist in today's environment. Under the FCSP, the levels of OC's have been measured annually in lake trout *(Salvelinus namaycush)* from Lake Ontario since 1977, Lake Erie since 1985, Lake Huron since 1980 and Lake Superior since 1980. Overall the levels of OC's have declined and now meet or are approaching targets set in the Great Lakes Water Quality Agreement (GLWQA). For example, total DDT (DDT and its metabolites- DDD and DDE) in whole fish tissue samples have been gradually decreasing at an average annual rate of 7.9%, such that the concentration of total DDT has not exceeded the GLWQA target of 1.0 µg/g in any individual fish since 2005 in the Canadian waters of the Great Lakes. *Keywords: Great Lakes basin, Pesticides, Fish.*

CLEVINGER, C.C., BADE, D.L., and HEATH, R.T., Department of Biological Sciences, Kent State University, Kent, oh, 44242. ***AmoA* gene quantification, nitrification, and oxygen demand in the Central Basin of Lake Erie.**

The role of nitrification in oxygen depletion in Lake Erie has received only limited attention. Nitrification is the prokaryotic chemoautotrophic process of ammonium oxidation.

Nitrification was detected using the 14C-method as the difference between samples inhibited with N-Serve vs. uninhibited controls. The amoA gene is central in this process by coding for the enzyme ammonium monooxygenase that catalyzes the first step of nitrification. Sampling of sediments and the water column was performed repetitively during 2008-9 at four Central Basin sites to evaluate the contribution of nitrification to the depletion of oxygen and to determine amoA gene copy number by qPCR. Nitrification in the water column consumed up to 80% of the total oxygen demand, while nitrification in the sediments accounted for up to 50% of the total oxygen demand in samples examined. AmoA gene copies in the sediments varied from 10^5 to 10^6 copies per gram dry weight of sediment; amoA gene copies in the water column varied from 10^4 to 10^5 copies per l. The presence of a gene that encodes an enzyme essential in nitrification coupled with differential oxygen consumption in inhibited vs. uninhibited samples suggests that nitrification was a significant process involved in oxygen depletion of benthic waters. *Keywords: Nitrogen, Biogeochemistry, Oxygen.*

CLIFFORD, A.M.[1], MCCLELLAND, G.B.[2], WANG, Y.S.[3], and WILKIE, M.P.[1], [1]Department of Biology, Wilfrid Laurier University, Waterloo, ON, N2L 3C5; [2]Department of Biology, McMaster University, Hamilton, ON, L8S 4K1; [3]Department of Biology, Queen's University, Kingston, ON, K7L 3N6. **Responses of Larval Sea Lampreys to Shorter-Term TFM Exposure and Restoration of Energy Reserves During a Post-TFM Recovery Period.**

As part of the sea lamprey control program, 3-trifluoromethyl-4-nitrophenol (TFM) is used as a selective pesticide that targets larval lampreys in their nursery streams. The selectivity of TFM is related to the lamprey's inability to detoxify the lampricide compared to non-target organisms. TFM exerts its toxicity in lampreys by interfering with ATP production in the mitochondria, leading to increased dependence upon anaerobic glycolysis for energy production. As a result, glycogen stores are depleted in brains and liver of lamprey exposed to TFM for 9-12h, a typical TFM treatment. Due to their relative inability to detoxify TFM, we predicted that lampreys would be unable to replenish energy reserves following shorter periods of TFM exposure, and that death would result during post-TFM recovery. Accordingly, 50 larval lamprey were exposed to a lethal TFM dose (12h-LC100) for 4h, and recovery followed for 24h. Approximately 70% of the larvae survived the shorter-term TFM treatment, and 80% of these survived the 24h post-TFM recovery. We suggest that recovery from TFM is probably due to the lamprey's ability to restore energy reserves when mitochondrial function is restored following TFM exposure. Thus, lowering TFM treatment times to 4h would likely reduce the effectiveness of lampricide treatments in the field. *Keywords: Sea lamprey, Pesticides, Toxicology, Invasive species, Metabolism, Lampricide.*

CLUBINE, N.G.[1], DESLOGES, J.R.[1], and ASHMORE, P.[2], [1]University of Toronto, 100 St. George St., Toronto, ON, M5S 3G3; [2]University of Western Ontario, 1151 Richmond St., London, ON, N6A 5C2. **A Quarter Century of Seasonal and Annual Sediment Yield Variations into Lake Huron from Ausable River, Ontario.**

Sediment yield into Lake Huron from the 1142 km2 Ausable River watershed, Ontario is controlled by suspended sediment response to flood events, hydrologic change and land use.

Twenty four years (1970-1993) of daily suspended sediment observation show that the spring nival melt dominates the flood record and yields the majority of annual sediment load. Multiple clock-wise hysteresis loops indicate a continuous supply of sediment during the early melt period. As the season progresses there is a tendency towards counter-clockwise loops suggesting delayed inputs from bank erosion and other watershed-wide sediment storage sinks. A time series of exponents for the twenty four spring season rating curves shows a weak trend towards a reduced response of sediment input from floods of an equivalent magnitude during the spring freshet. River entrenchment and land use changes are possible contributing factors. The Ausable River has one of the highest specific sediment yields of rivers flowing into Lake Huron from the eastern (Canadian) side. Tall glacial embankments exposed in the lower river reaches are a significant sediment source. Total annual sediment loads from the Ausable River have declined significantly over the last quarter century and this follows the same trend of several other rivers entering the eastern Lake Huron shore. *Keywords: Lake Huron, Sediment response to hydrologic change, Sediment load.*

COMAN, M. and WELLS, M.G., Department of Physical and Environmental Sciences, 1265 Military Trail, Toronto, ON, M1C1A4. **Physical Mechanisms of the Spatial and Temporal Water Temperature Variations in Lake Openogo.**

Previous work has found a link between the surface wind direction and temperature variation in the littoral zone of Lake Openogo. We aim to understand the physical reasons behind the observed spatial and temporal variability. We examine 2009 temperature data from thermistor strings in the upper water column of Lake Opeongo, Ontario, Canada. The thermistor strings were located at strategic positions throughout the lake, encompassing in-shore and off-shore locations and steep and shallow bottom slope conditions. With this array of thermistors and surface wind data, we calculate a measure of the temporal temperature variability and compare this to the local Lake Number, for each different site. We find low values for the Lake Number in the Spring while the thermocline is still developing. In the Summer and Autumn a low Lake Number typically relates to high temperature variability and a high Lake Number relates to small temperature variability. As has previously been observed, we also find the upwind sites show more temperature variability than the downwind sites. Using this data set we present an overall picture of the physical processes operating in Lake Openogo. *Keywords: Water currents, Lake model.*

COOKE, S.J.[1] and THORSTAD, E.B.[2], [1]Biology Department, Carleton University, Ottawa, ON, K1S 5B6, Canada; [2]Fisheries Group, Norwegian Institute of Nature Research, Trondheim, Norway. **The changing role of radio telemetry in studies of freshwater ichthyofauna relative to other tagging and telemetry technology: a review.**

Radio telemetry is now considered a standard tool for fisheries professionals studying fish in freshwater systems. However, interest in radio telemetry technology may be waning in popularity relative to other technologies (e.g., acoustic telemetry, passive integrated transponders) which have recently become popular for tracking studies in freshwater. The purpose of this presentation is to identify the unique characteristics of radio telemetry that

continue to make it an extremely powerful tool for elucidating the fundamental biology of aquatic organisms, particularly those living in shallow, fluvial habitats, and in providing information to enable effective management and conservation of aquatic resources (e.g., particularly related to the Laurentian Great Lakes). By evaluating the peer-reviewed literature on radio telemetry in aquatic systems over a ten year period, we summarized the advances in fisheries science owing to radio telemetry and identify trends related to study design, tagging techniques, and tracking strategies. Based on this synthesis and our experience, we also identified research questions and management needs that can not be effectively addressed using technologies other than radio telemetry. *Keywords: Fish behavior, Fisheries, Fish tagging.*

COPPAWAY, C.W.[1], MCLAUGHLIN, R.[1], and MACKERETH, R.[2], [1]University of Guelph, 50 Stone Rd. East, Guelph, ON, N1G2W1, Canada; [2]Lakehead University, 955 Oliver Road, Thunder Bay, ON, P7B5E1, Canada. **The Dynamics of Brook Charr (Salvelinus fontinalis) 'Residency' in Lake Superior Tributaries.**

This study investigated the nature of stream residency in migratory populations of brook charr (Salvelinus fontinalis) from Lake Superior. Migratory systems can be complex, with individuals differing in their propensity to migrate and the form and timing of their migratory movements. Some populations of Lake Superior brook charr have two ecotypes: a small form that purportedly remains in the stream environment throughout its life and a large ecotype that migrates from the stream to the lake (partial migration). We used electro-fishing surveys and passive integrated transponder tags, and stable isotopic tissue analysis to test whether individuals captured in a tributary remained in that tributary (resident), made diel foraging migrations from the tributary to the lake, or moved from tributary to tributary (vagrant stream specialist). Data analysis from this two year study suggests most tagged individuals remained in the same tributary some moved from the tributary to the lake and returned to the tributary, with few moving between tributaries. This data indicates that the movement ecology of purported stream residents may be more complex and important to the management of Lake Superior brook charr than was previously appreciated. *Keywords: Stable isotopes, Remote sensing, Brook charr, Fish behavior.*

COPPLESTONE, D. and MACDONALD, F., 4601 Guthrie Dr., Peterborough, ON, K9J 8L5. **The Invading Species Hit Squad – Spreading Awareness Through Monitoring, Education, and Outreach.**

The Invading Species Hit Squad hit the ground running again, with a record 20 students working to educate and engage their communities in invasive species prevention, monitoring and control activities. Staff worked with local partners in Kenora, Fort Frances, Thunder Bay, Nipigon, Sault Ste. Marie, Windsor, Chapleau, Manitoulin, Orillia, Alliston, Aurora, Peterborough, Trenton, Picton, Finch, Lanark (2), Ottawa, Pembroke and Hawkesbury. The Hit Squad participated in 99 events, providing presentations and displays and watercraft inspections at boat launches, and campsite surveys at provincial parks. A new partnership with Ontario Parks enabled students to attend 28 provincial parks and assist with interpretive programs. Students also engaged numerous volunteers to monitor 147 lakes, and worked hard to attract media

attention to invasive species issues, writing articles for local papers and doing media interviews. These initiatives were made possible through funding from local partners and the Canada Summer Jobs program. *Keywords: Outreach, Monitoring.*

COTNER, J.B.[1], CORY, R.M.[2], MCNEILL, K.P.[3], JACOBSON, M.[1], PETERSON, B.P.[3], and AMADO, A.M.[4], [1]Department of Ecology, Evolution and Behavior, University of Minnesota-Twin Cities, Saint Paul, MN, 55108, United States; [2]Department of Environmental Sciences and Engineering, University of North Carolinal, Chapel Hill, NC, 27599, United States; [3]Department of Environmental Science, ETH Zurich, Zurich, Switzerland; [4]Department of Oceanography and Limnology, Federal University of Rio Grande of the North, Natal, 59014, Brazil. **Fluorescent dissolved organic matter helps unravel the carbon cycle in Earth's largest lake.**

Lake Superior, an ultra-oligotrophic lake contains a large pool of organic carbon (1.5 to 1.9 x 1013 g), despite low dissolved organic carbon (DOC) concentrations of 1-2 mg C L-1. While Lake Superior is already experiencing climate change impacts such as increasing temperatures and extended periods of summer stratification, there remain key uncertainties in the carbon and nitrogen cycles that center on the source and quality of dissolved organic matter (DOM) in Lake Superior. We employed absorbance and fluorescence spectroscopy to asses the sources and dynamics of the colored and fluorescent fraction of DOM in Lake Superior and one its major tributaries in much greater spatial and temporal resolution than has previously been done, by collecting samples throughout the water column on eight cruises spanning May through October, 2006-2008. Parallel factor analysis (PARAFAC) of the fluorescent fraction of DOM (FDOM) revealed six unique components originating from terrestrial, autochthonous, and/or proteinacous precursor material. The general pattern obtained from the CDOM and FDOM patterns in Lake Superior was a strong removal of terrestrially-derived humic DOM with increasing importance and variability in DOM associated with autochthonous sources along the riverine to open Lake Su *Keywords: Carbon cycle, Climate change, Dissolved organic matter.*

CREECH, C.C., MCKEEVER, A., SELEGEAN, J.P., and DAHL, T.A., US Army Corps of Engineers, 477 Michigan Avenue, Detroit, MI, 48226. **The Ontonagon River: A History of Sediment Yields in a Geologically Young Watershed.**

Early Great Lakes explorers such as Cass and Schoolcraft found the Great Lakes basin predominately absent of anthropogenic alterations including logging, agriculture, and urbanization. Despite this fact, when Schoolcraft explored the Ontonagon River in 1820, he found significant bank erosion, mass wasting, and gully incision. This study explores the pre-European conditions of the Ontonagon River watershed and calculates historic (geologic) and modern sediment yields. To quantify geologic erosion rates, a Geographic Information System (GIS) model, which reconstructed the likely watershed topography at the start of the Holocene, was developed. Modern sediment yields were computed from US Army Corps of Engineers harbor soundings and US Geologic Survey sediment data. From this analysis it was found that the watershed has not yet reached a point of dynamic equilibrium, but instead can be described as being in a "geologically young" state. *Keywords: Hydrogeomorphology, Ontonagon, Sediment load, GIS.*

CRIMMINS, B.[1], XIA, X.[1], PAGANO, P.[2], MILLIGAN, M.[3], HOPKE, P.[1], and HOLSEN, T.[1], [1]Clarkson University, Potsdam, NY; [2]SUNY Oswego, Oswego, NY; [3]SUNY Fredonia, Fredonia, NY.
Quantitative Screening of Emerging Contaminants in Lake Michigan Lake Trout.

The Great Lakes Fish Monitoring Program (GLFMP) began in 1980 to assess the contaminant burden in Great Lakes fish. During the past three decades an increasing number of organic toxics, such as brominated flame retardants, have been identified in biological matrices. Recently, a list of potential emerging contaminants was developed (Muir and Howard, 2009, http://www.epa.gov/grtlakes/p2/PBT_progress.pdf) identifying individual and classes of compounds of concern based on production volume and physical/chemical properties. As part of the GLFMP it is imperative to assess the burden of newly identified contaminants in the Great Lakes. The not-so-obvious next step is to address the analyzability of each compound to quantitatively determine its distribution in lake trout. Currently a detailed evaluation of the applicability of current-use methods for the analysis of several halogenated compounds listed by Muir and Howard (2009) is underway. These include pentabromochlorocyclohexane, hexachlorocyclopentadiene, 2-ethylhexyl-2, 3, 4, 5-tetrabromobenzoate (TBB), (2-ethoxyl) tetrabromophthalate (TBPH) and pentachloropyridine. The method performance, detection limits and measured concentrations of detected analytes in Lake Michigan lake trout will be presented. *Keywords: Environmental contaminants, Lake trout, Organic compounds.*

CROWE, A.S.[1] and ROBINSON, C.[2], [1]Environment Canada, Canada Centre for Inland Waters, Burlington, ON, L7R4A6; [2]Department of Civil & Environmental Engineering, University of Western Ontario, London, ON, N6A5B9.
Quantification of Groundwater Discharge from Beaches into the Great Lakes.

It is estimated that groundwater contributes much of the water found within the Great Lakes. However, there are no estimates of groundwater discharge from beaches along the shores of the Great Lakes. Nor is much known about characteristics of groundwater flow below beaches. Although the vast majority of beaches occupy only a narrow width of the shore, generally 50 m to 200 m wide, beach represent a large proportion of the shoreline of the Great Lakes. Field measurements at several beaches throughout the Great Lakes and numerical modelling analyses were undertaken to assess groundwater conditions below beaches and groundwater discharge to the lakes. Lakeward of the shoreline, groundwater is primarily terrestrially derived (e.g., precipitation, inland aquifers). Groundwater flows towards the shoreline throughout the year, and discharges within a few meters of the shoreline. Given the high hydraulic gradients below beaches and the high hydraulic conductivity of beach sand, groundwater velocities below beaches are very high (0.4 to 10 m/d). Thus, contaminants entering the shallow unconfined beach aquifer will rapidly end up in the lake. Numerical modelling was used to quantify groundwater discharge rates and locations at a number of beaches with different morphological, hydrogeological and recharge characteristics. *Keywords: Groundwater, Beaches.*

CROWE, A.S.[1], LECLERC, N.[2], STRUGER, J.[1], and BROWN, S.[1], [1]Environment Canada, Canada Centre for Inland Waters, Burlington, ON, L7R4A6; [2]Wasaga Beach Provincial Park, 11-22nd Street North, Wasaga Beach, ON, L9Z 2V9.
Persistence of Glyphosate in groundwater and nearshore lake water following the application of Roundup® to Phragmites at a beach on Southern Georgian Bay.

During the past decade, the invasive *Phragmites Australis* (common reed) has established itself along beaches of the Great Lakes, causing detrimental impacts to the natural ecological integrity of the shoreline and the recreational value of the beaches. The most effective method to eradicate Phragmites is by the application of the herbicide Roundup®. Phragmites grows within a few meters of the shoreline, and thus there is concern that the active ingredient of Roundup®, glyphosate, may enter the nearshore lake water via runoff or by groundwater discharge. Wasaga Beach Provincial Park applied Roundup® to Phragmites during October 2009, and groundwater and lake water was tested to determine if glyphosate enters the groundwater and lake, what are its concentrations, and how long it will persist. Glyphosate was detected in the groundwater below the Phragmites. Two days after application, the geometric mean concentration was 0.60 μg/L. However, concentrations declined over the next two weeks to MDL. Glyphosate was also detected in the nearshore lake water with concentrations peaking at 0.14 μg/L one week after application and declining to 0.039 μg/L 4 weeks after application. Although glyphosate was detected in the groundwater and lake water, concentrations never exceeded the water quality guideline of 65 μg/L. *Keywords: Pesticides, Groundwater, Beaches, Phragmites.*

CSISZAR, S.A.[1], DAGGUPATY, S.[2], and DIAMOND, M.L.[3], [1]Department of Chemical Engineering and Applied Chemistry, University of Toronto, Toronto, ON, M5S 3E5; [2]Science and Technology Branch, Environment Canada, Toronto, ON, M3H 5T4; [3]Department of Geogpraphy, University of Toronto, Toronto, ON, M5S 3G3.
BLFM-MUM: A Coupled Atmospheric Transport and Multimedia Model Used to Study PCBs in Toronto.

Urban areas are PCB sources and previous studies using the Multimedia Urban Model (MUM) suggest that air transport dominates PCB fate out of urban areas (Diamond et al. 2010). To quantify PCB emissions and fate we have coupled the MUM with the boundary layer forecast model (BLFM) (Daggupaty et al. 1994; Daggupaty 2001; Ma et al. 2003). BLFM can capture lake breeze and urban wind effects on the transport of PCBs to surrounding areas including Lake Ontario. The coupled model allows us to simulate interactions between air and the city via the MUM compartments water, soil, sediment, vegetation, and film. The model area is divided into 25 km2 grids allowing us to study PCB movement within the city on a relatively small scale. This spatial localization further allows us to estimate chemical emissions coming from different areas of the city. Input to the model includes a spatial PCB inventory which indicates that PCB usage is concentrated, although not limited to, the city's downtown core (Diamond et al. 2010). BLFM-MUM can be further used to study other contaminants such as PBDEs. *Keywords: Model studies, PCBs, Urban areas.*

CUDMORE, B.C., Centre of Expertise for Aquatic Risk Assessment, Fisheries and Oceans Canada, 867 Lakeshore Rd., Burlington, ON, L7R 4A6. **Using Risk Assessment to Inform Aquatic Invasive Species Prevention Strategies.**

With Great Lakes resource managers facing the ongoing threat of aquatic invasive species in light of limited resources, the most cost-effective solution has been to focus programs on prevention. However, if prevention is the key component of an aquatic invasive species program, how do we determine what species and pathways to focus on? The solution is to use risk assessments to inform aquatic invasive species prevention strategies. The general framework on which biological risk assessments are based assesses the probability of an introduction of an aquatic invasive species and the magnitude of the consequences of that introduction to conclude an overall statement of risk. Risk assessments identify those species of greatest risk and the pathways these species use. This enables decision-makers and managers to set up 'road blocks' to prevent the species' movement into an area of concern. Risk assessments can also provide information for other preventative strategies, such as monitoring and early detection, rapid response, and education and public outreach initiatives. Specific examples from completed risk assessments by the Centre of Expertise for Aquatic Risk Assessment will be used to highlight how risk assessment can be used to solve problems in identifying prevention strategies. *Keywords: Biological invasions, Fish management, Risk assessment.*

CVETKOVIC, M., DE CATANZARO, R., and CHOW-FRASER, P., McMaster University, Hamilton, ON. **Road Density as a Simple Indicator to Assess Habitat Quality of Coastal Marshes of the Laurentian Great Lakes.**

We used a Geographic Information System to calculate the road density (RD) of 59 Great Lakes coastal watersheds that included heavily impacted areas of Lakes Erie and Ontario, and relatively unimpacted areas of Georgian Bay, Lake Huron. RD was an effective measure of human disturbance, as primary nutrients and conductivity increased significantly with RD ($p<0.05$), both when data were analyzed separately for Georgian Bay and when they were combined with more degraded sites in Lakes Erie and Ontario. Number of exotic fish correlated significantly with RD, as did index scores of three published ecological indices. While RD in Georgian Bay watersheds was on average 6 times lower than RD in the Lower Lakes, a few wetlands with heavy surrounding cottage development showed symptoms of water-quality impairment similar to those in settled areas of the lower Great Lakes. Wetlands showed signs of degradation above a RD threshold of 14 m•ha-1 and we recommend that this level be used to guide conservation efforts to protect Great Lakes coastal marshes. *Keywords: Ecosystem health, Coastal wetlands, Indicators.*

CYR, H., Dept. Ecology & Evolutionary Biology, University of Toronto, RWZL, 25 Harbord Street, Toronto, ON, M5S 3G5. **The Spatial and Temporal Variability in Nutrient Limitation of Phytoplankton in Nearshore Areas: the Importance of Physical Forces.**

Nearshore sediments are a potential source of nutrients to the water column. Under the right conditions, phosphorus and nitrogen are released into oxic waters by diffusion, pumping of

sediment porewater and/or resuspension of sediments. Physical forces (e.g. currents, surface waves, upwellings, internal waves) can enhance the exchange of nutrients in nearshore areas, but these effects are difficult to measure because bacteria and algae rapidly take up these released nutrients. In this study, I compared the type and extent of nutrient limitation in inshore and offshore phytoplankton on 8 days with different wind conditions. The magnitude of nutrient limitation was measured in 3 ways: 1) in situ chlorophyll-specific alkaline phosphatase activity, 2) changes in algal growth rates in nutrient addition experiments, 3) suppression of alkaline phosphatase activity in nutrient addition experiments. The type and magnitude of nutrient limitation varied both spatially and temporally, and was partly related to wind intensity and site exposure. Different measures of nutrient limitation complement each other, but must be interpreted carefully. *Keywords: Phytoplankton, Nutrients, Littoral zone.*

CZESNY, S.[1], MICHALAK, P.[2], and EPIFANIO, J.[1], [1]Illinois Natural History Survey, University of Illinois, 400 17th Street, Zion, IL, 60099, US; [2]University of Texas at Arlington, 501 S. Nedderman, Arlington, TX, 76010, US. **Exploring adaptive plasticity of alewife (Alosa pseudoharengus) to better manage fisheries in the Great Lakes.**

Alewife invaded the Great Lakes between 1860 and 1955. Its ecological success and adaptive ability offer an intriguing avenue to test for parallel evolution, as a suite of similar traits in different lineages provides insights into the mechanism of ongoing natural selection. A long-puzzling question is whether convergent suites of adaptive phenotypes are determined by the same or different genetic changes. To address this question, we used alewife whose populations occur in two discrete morphological and ecological forms, an anadromous (Atlantic Ocean) and a landlocked (Lake Michigan). Divergent adaptations to marine vs. freshwater environments result in dramatic life-history differences between these two alewife populations. Landlocked alewives mature earlier, growth slower, and have reduced fecundity relative to anadromous alewives. Unlike anadromous populations, landlocked alewife populations are reproductively isolated and thus provide a striking example of rapid parallel evolution. Using high-throughput 454 pyrosequencing we examined sequence and gene expression polymorphism in relation to ecological conditions and the origin of alewives. To test the hypothesis of molecular adaptation to marine vs. freshwater environment, tissue specific gene expression profiles of candidate genes for local adaptation were compared. *Keywords: Alewife, Genetics, Exotic species.*

CZESNY, S.J.[1], RINCHARD, J.[2], DETTMERS, J.M.[3], DABROWSKI, K.[4], and HANSON, D.[5], [1]Illinois Natural History Survey, University of Illinois, lake Michigan Biological Station, 400 17th Street, Zion, IL, 60099, US; [2]The College at Brockport – State University of New-York, 350 New Campus Drive, Brockport, NY, 14420, US; [3]Great Lakes Fishery Commission, 2100 Commonwealth Blvd, Suite 100, Ann Arbor, MI, 48105, US; [4]The Ohio State University, 2021 Coffey Road, Columbus, OH, 43210, US; [5]U.S. Fish and Wildlife Service, Green Bay Fishery Resources Office, 2661 Scott Tower Drive, New Franken, WI, 54229, US. **Exploring sources of variability in lipid content and fatty acid signatures of Lake Michigan forage fish and invertebrates.**

Non-indigenous species may alter trophic pathways resulting in deleterious impacts to native fish communities. To better understand the trophic structure in Lake Michigan, lipid content and fatty acid profiles of common forage species/taxa groups were determined. Discriminant function analysis performed on 13 species/taxa groups using the 18 most abundant fatty acids revealed clear separation among taxa with overall classification success reaching 89% in spite of within species variation. Sizable annual (alewife) and seasonal (alewife, rainbow smelt, and round goby) variation in fatty acid signatures was also noted allowing for within species discrimination based on years and seasons with high classification success. Body size (alewife and round goby) and sampling location (alewife) had significant effects on fatty acid composition, which likely related to known ontogenetic diet shifts in these species and spatial variation in prey assemblage and zooplankton composition between southern and northern sites in Lake Michigan. Despite various sources of variation, within-species variability was relatively small compared to among-species variability in fatty acid profiles. Thus, fatty acid signatures can be used in freshwater systems to study food web interactions and delineate spatial-temporal changes in food web structure. *Keywords: Food chains, Alewife, Lake Michigan, Fatty acids, Round goby.*

D'ANDREA, M.[1], BOWERING, T.[1], SHAPIRO, H.[2], PATEL, M.[2], and EDGE, T.[3], [1]City of Toronto, Metro Hall, Station 1180, 55 John Street, 18th Floor, Toronto, ON, M5V3C6; [2]Toronto Public Health, 2340 Dundas Street West, Toronto, ON, M6P4A9; [3]Environment Canada, 351 St. Joseph Boulevard, Place Vincent Massey, 8th Floor, Gatineau, QU, K1A0H3. **Toronto Beaches: Past, Present & Future Management.**

This paper traces the Beaches and Water Quality Improvement History for Toronto's over 11 beaches from 1880 to present. It outlines the relative role that direct discharges and more recently wildlife and waterbirds play as pollution sources. It presents the Toronto Beaches Plan, which is a strategy to make our beaches even more swimmable, as part of a clean, green and beautiful waterfront. It summarizes the many 'softer' measures included in Beach "Management" Activities which has assisted in achieving the Blue Flag Status of 5 beaches (Exploring relocating two beaches, Improved beach grooming, Waterfowl diversion & egg oiling, use of Border Collies to control waterfowl/ waterbirds, Public education) *Keywords: Pollution sources, Water quality, Public education.*

DANESHFAR, B., JARVIS, I., EILERS, W., and HUFFMAN, T., Agriculture and Agri-Food Canada, KW Neatby Building, 960 Carling Avenue, Ottawa, ON, K1A 0C6. **Agricultural Land Use Change at Watershed Level_ Present and Future Possibilities.**

Agriculture and Agri-Food Canada, in collaboration with Statistics Canada's Agriculture Division, developed a process for "interpolating" (reallocating or proportioning) Census of Agriculture information from census polygon-based units to biophysical polygon-based units (e.g. soils and watersheds). The Interpolated Census of Agriculture has been the main source of information to study spatial and temporal distribution and variation of agricultural land use change or derived variables from census of agriculture at watershed levels. In this study it will demonstrated how this information can be applied in such analyses. In addition, limitations

related to spatial and temporal resolution of this source of information will be explained and new approaches at Agriculture and Agri-Food Canada to increase both spatial and temporal resolution of agricultural land use variables based on processing satellite images will be introduced. *Keywords: Spatial analysis, Watersheds.*

DAS, S.[1], SWEENEY, S.J.[1], GOEL, P.K.[2], and MCKAGUE, K.[1], [1]Ontario Ministry of Agriculture, Food and Rural Affairs, Guelph, ON, N1G 4Y2; [2]Ontario Ministry of Agriculture, Food and Rural Affairs, Guelph, ON, N1G 4Y2. **Database challenges for modelling efforts in southern Ontario Great Lakes-tributary watersheds over the decade from 2000-2009.**

The most recent decade (2000-2009) witnessed tremendous advances in water quality model development and implementation throughout the world. Correspondingly, the input data used to run these models continued to improve as well – although its quality and availability remain as significant challenges for researchers. Coverage of southern Ontario Great Lakes-tributary watersheds by modelling efforts also expanded over that time period. To date no comprehensive spatial database with model-ready input information has been built for the Province. Observed stream flows and pertinent water quality data are essential for calibration and validation of models. This paper will describe several modelling projects conducted at a range of scales in the 2000-2009 decade for southern Ontario watersheds. This discussion will outline the evolution and current availability of the requisite input databases for water quantity and quality, climate, terrain models, soils and land management. *Keywords: Model studies, Great Lakes basin, Water quality.*

DAVIS,, G.[1], ZONDAG, R.[2], LICHTKOPPLER, F.[3], and ORNDORFF, M.[4], [1]The Ohio State University, OSU Extension,, 2120 Fyffe Road,, Columbus, OH, 43210; [2]The Ohio State University, OSU Extension,, Lake County, Western Reserve EERA, 99 East Erie Street, Painesville, OH, 44077; [3]The Ohio State University, OSU Extension, Ohio Sea Grant, 99 East Erie Street, Painesville, OH, 44077; [4]Lake County Soil and Water Conservation District, 125 East Erie Street, Painesville, OH, 44077. **Lake County Nursery Industry Survey: A Case Study of Applied Research.**

The unique soils and micro-climate of coastal Great Lakes counties make them a prime spot for growing nursery stock and other high value agricultural products. This industry is facing increased economic pressures and needs applied economic research information if it is to survive as a viable part of the coastal community. Information on the economic impact of the industry is valuable in developing strategies to help protect and preserve this unique coastal agriculture. The average Lake County Nursery Industry (LCNI) firm has sales of $605,000 of container grown crops and $488,000 of field grown crops. The typical firm has been in business almost 35 years, is headed by an owner over 50 years of age, and employs about 2 family members, 11 permanent full time employees and about 23 seasonal employees. Total LCNI employment in 80 commercial nursery firms is estimated at 1,327 FTE jobs, they have a payroll of over $30 million and total estimated annual sales of $87.5 million. Ways in which this information have and will be used will be discussed. *Keywords: Economics Case Study, Conservation, Education, Assessments, Applied Research.*

DE SILVA, A.O.[1], SMALL, J.[1], WILLIAMSON, M.[1], BACKUS, S.[2], and MUIR, D.C.G.[1], [1]Aquatic Ecosystem Protection Division, Environment Canada, Burlington, ON, L7R 4A6; [2]Water Quality Monitoring and Surveillance, Environment Canada, Burlington, ON, L7R 4A6. **Perfluorinated Acids in the Current Lake Ontario Foodweb.**

Recent studies indicate significant changes to the food web structure of Lake Ontario, due in part to the proliferation of invasive species. Lake trout are a top predator in Lake Ontario and their pelagic fish prey consist of rainbow smelt, slimy sculpin, round goby, and alewife. In this research, the extent of perfluorinated acid (PFAs) contamination in the Lake Ontario foodweb was evaluated. Whole body specimens were collected in Summer/Fall 2008 by Environment Canada's Fish Contaminant Monitoring & Surveillance Program. Forage fish were homogenized and combined into composite samples. PFAs were extracted using acetonitrile, followed by carbon clean-up for LC-MS/MS analysis. Consistent with results by Martin et al. 2004, higher PFA concentrations were observed in benthic species, sculpin and the burrowing amphipod, Diporeia. Of the PFAs analyzed, perfluorooctane sulfonate (PFOS) is the predominant contaminant. Mean (+/- RSD) PFOS wet wt. concentrations were 52 ng/g (0.2) in trout, 30 ng/g (0.5) in alewife, 19 ng/g (0.4) in goby, 34 ng/g (0.4) in smelt, and ng/g (0.5) in sculpin. PFOS in invertebrates were 92 ng/g (0.2) in Diporeia, 5.3 ng/g (0.4) in mysis, 4.9 ng/g (0.4) in plankton.Carbon and nitrogen stable isotopes were used to further interpret these results with particular focus on changes in trophic levels. *Keywords: Biomagnification, Lake Ontario, Perfluorooctane sulfonate.*

DE SOLLA, S.R.[1], STRUGER, J.[2], and MCDANIEL, T.V.[2], [1]Wildlife and Landscape Science Directorate, Environment Canada, Burlington, ON, L7R 4A6; [2]Water Science and Technology Directorate, Environment Canada, Burlington, ON, L7R 4A6. **The influence of detection limits on the interpretation of pesticide data in surface waters, particularly in regards to monitoring programs.**

Water quality monitoring programs rely on residue data that are frequently left censored, due some observations being below the Method Detection Limits (MDLs). Our objective was to determine the influence the MDL has on the interpretation of pesticide residues in surface waters. Water samples from tributaries in southern and central Ontario that were collected from 2003-2007 were analyzed for 36 pesticides, with MDLs that averaged 16.04 ng/L (range 0.37 to 79.5 ng/L). We then simulated MDLs ranging from 25 to 1700 ng/L, to determine the impact on the reporting of pesticides. The mean number of pesticides detected simultaneously declined with increasing MDL, from 5.6 pesticides (native MDL) to 0.08 pesticides detected (> 1700 ng/L MDL; Fig. 2). Even a seemingly mild reduction in sensitivity, from an average MDL of 16 ng/L to 25 ng/L, reduced the number of pesticides detected by 45%. Depending on the method of substitution for observations below MDL (replacement with ½× or 0× MDL), the mean and median pesticide residues became increasingly over- and underestimated, respectively. Although monitoring programs that are focused on exceedences of water quality guidelines may not require low MDLs, the achievable goals of monitoring programs oriented towards other objectives may be limited by higher MDLs. *Keywords: Amphibians, Pesticides, Monitoring.*

DE SOLLA, S.R.[1], PELLETIER, E.[2], and LETCHER, R.J.[2], [1]Wildlife and Landscape Science Directorate, Environment Canada, Burlington, ON, L7R 4A6; [2]Wildlife and Landscape Science Directorate, Environment Canada, Ottawa, ON, K1A 0H3. **Perfluorinated compounds in snapping turtle plasma from two Canadian Ares of Concern.**

Perfluorinated compounds (PFCs) are a broad class of chemicals that are used as stain repellents, surfactants, flame retardants, and in other applications, but also include degradation products of other PFC precursors. Seventeen PFCs were measured in plasma of male snapping turtles (*Chelydra serpentina*) collected from 3 sites in Ontario, including two Areas of Concern; the reference site Lake Niapenco (Binbrook), Humber River (Toronto AOC), and Cootes Paradise (Hamilton Harbour AOC). Both AOC sites were within large urban areas, and both were close to sewage treatment plants (STPs). Lake Niapenco is a rural site, with no nearby STPs or local industry. Unexpectedly, mean concentrations were highest at Lake Niapenco (2.1 ug/g), compared to the Humber River (0.12 ug/g) and Cootes Paradise (0.53 ug/g). PFOS and PFHxS comprised ~99.8% of sum PFCs at Lake Niapenco, and 86-88% at the other two site. PFOS and PFHxS were both used in fire fighting foams. There is a important but currently unidentified source of PFCs, particularly PFOS, in or upstream of the rural "reference" site. Future work may be focused on attempting to identify this source. *Keywords: Monitoring, Reptile, Perfluorooctane sulfonate, Trophic level.*

DEBRUYNE, R.L.[1], DEVAULT, T.L.[2], POGMORE, F.E.[3], RUDSTAM, L.G.[1], JACKSON, J.R.[1], CHEN, Q.L.[1], and WU, K.J.[1], [1]Cornell Biological Field Station, Cornell University, 900 Shackelton Point Rd, Bridgeport, NY, 13030; [2]USDA Wildlife Services, National Wildlife Research Center, Ohio Field Station, 6100 Columbus Avenue, Sandusky, OH, 44870; [3]USDA, APHIS, Wildlife Services, 617 Comstock Rd, Suite 9, Berlin, VT, 5602; [4]Cornell Biological Field Station, Cornell University, 900 Shackelton Point Rd, Bridgeport, NY, 13030. **Location, Location, Location: Cormorant Diets from Four Sites on Lake Champlain.**

Double-crested cormorants receive much attention due to their increasing population numbers in the Great Lakes region and on Lake Champlain. Previous diet studies of cormorants on Lake Champlain indicated potential negative impacts to the yellow perch population. However, with the invasion of alewives into the lake in 2003, the fish community has changed and cormorants may be feeding on the new forage fish available. We examine the diet of cormorants from four areas of Lake Champlain to assess the current and potential future impacts of cormorants to the changing fish community. During the breeding seasons of 2008 and 2009, spatial and temporal differences in cormorant diets were observed, as well as differences between the years. Alewives were heavily consumed at Four Brothers Islands (54% and 69% yearly weight totals) and South Sea (65% and 61%) sites in both years, with yellow perch predominately consumed at Young Island (43% and 58%). Other frequently occurring diet items were rainbow smelt, cyprinids, white perch, and *Lepomis* spp. The relative importance index values of specific diet items changed as the season progressed. These data demonstrate that the diet of piscivorous birds may vary significantly within a single large water body, and that ideally, management efforts should be site specific. *Keywords: Cormorants, Diets, Alewife.*

DECATANZARO, R. and CHOW-FRASER, P., McMaster University Department of Biology, 1280 Main St West, Hamilton, ON, L8S 4L8. **Landscape and seasonal controls on water chemistry of coastal marshes in eastern Georgian Bay.**

Water chemistry of Great Lakes coastal marshes can vary considerably in the absence of human influence. We surveyed 34 marshes in relatively pristine catchments of eastern Georgian Bay in spring and summer of 2009 for nutrient and physical parameters and examined their relationships to characteristics of the marsh and its drainage basin. The first principal component explained 46.1% of variation in landscape variables and ordered marshes along a gradient with high values corresponding to large, high-order watersheds containing extensive upstream wetland. This axis was negatively related to specific conductivity, pH, nitrate nitrogen and SO_4^{2-} concentrations and positively related to total phosphorus, colour, suspended solids and summer dissolved organic carbon. Drainage basin area or order alone explained up to 44% of some marsh water-chemistry variables. Changes in water-chemistry parameters between April and July sampling periods were consistent for marshes draining high- and low-order catchments. Overall, watershed influence was most evident in marshes draining large, high-order watersheds, and during spring snowmelt. These marshes may be most susceptible to impacts from altered hydrology and land development in their watershed. *Keywords: Coastal wetlands, Water quality, Watersheds.*

DEFORE, A.L. and BIDDANDA, B.A., Grand Valley State University, Annis Water Resources Institute, Muskegon, MI, 49441. **Carbon Cycling in Muskegon Lake: What's Driving It?**

Studies quantifying the annual seasonal cycle of nutrients and carbon by autotrophic and heterotrophic communities in gross primary production (GPP) and respiration (R) in the freshwater aquatic environment are seriously lacking, but crucial to our understanding of the carbon cycle. Beginning in February 2009 changes in lake metabolism, associated environmental variables and the trophic relationship between phytoplankton and bacterioplankton were investigated to identify events and time frames in which Muskegon Lake (a drowned river mouth lake directly connected to Lake Michigan) becomes a source or sink of carbon. GPP and R were measured monthly to obtain a complete representation of community metabolism and the rate at which these communities control energy flow, nutrients and organic matter storage. Metabolism indices show Muskegon Lake as a highly productive autotrophic system in the spring and summer with a GPP/R of 2.4 then becoming a heterotrophic system in late fall with a GPP/R of .042. Experimental additions of nitrogen and phosphorous, stimulated GPP, whereas dissolved organic matter selectively stimulated R. Studies of lake metabolism provide a useful holistic indicator of lake response to changing environmental conditions and contribute to our understanding of the role of lakes in the regional carbon cycle. *Keywords: Metabolism, Carbon cycle, Biogeochemistry.*

DEKKER, T.J.[1], LAUTENBACH, D.L.[1], SELVENDIRAN, P.[1], GRUSH, J.[1], APFELBAUM, S.I.[2], SHEPARD, G.[3], and WEBSTER, B.[4], [1]LimnoTech, 501 Avis Drive, Ann Arbor, MI,

48108; [2]Applied Ecological Services, Brodhead, WI; [3]Michael Van Valkenburgh Associates, New York, NY; [4]WATERFRONToronto, Toronto, ON.
Evaluating Hydrology, Flooding, Sediment Transport and Ecology within the Lower Don Lands Naturalization Project.

The Lower Don Lands Area of Toronto is located at the intersection of three emerging Toronto neighborhoods near the mouth of the lower Don River, an industrialized river mouth. In recent years, demand for restoration of the river mouth area has increased, while the emerging neighborhoods have driven a need for balance between the urban environment and the hydrologic and ecologic requirements of the river mouth. The design was developed as a multidisciplinary, creative effort supported by a strong understanding of hydrology, freshwater estuarine ecology, and hydrologic and ecological interactions with Lake Ontario. The result is a proposal to create a restored river mouth with natural meanders, wetland margins, wildlife habitat, and recreational opportunities. The plan also retains and enhances the function of the lower Don as a floodway, greatly increasing floodwater conveyance capacity to allow passage of the most extreme regulatory flood event while incorporating sediment management needs through dredging and reuse of recovered solids. These critical elements for project success were evaluated through the use of several hydrodynamic and sediment transport models developed by the project team and by the TRCA, allowing designers to understand competing site needs, and providing confidence in the ultimate site design. *Keywords: Ecosystems, Hydrodynamic model, Lake Ontario.*

DELONG, E.D.[1], BHAVSAR, S.[2], MIERLE, G.[3], and CAMPBELL, L.M.[1], [1]Queen's University, Department of Biology, Kingston, ON, K7L 3N6; [2]Ontario Ministry of Environment, Biomonitoring, Environmental Monitoring & Reporting Branch, 125 Resources Road, Etobicoke, ON, M9P 3V6; [3]Ontario Ministry of Environment, Dorset Environmental Research Centre, P.O. Box 39, Dorset, ON, P0A 1EO.
An Evaluation of Model-Based Prediction of Mercury Contaminant Concentrations in Ontario Sport Fish.

Mercury (Hg) levels in sport fish have been continuously collected across Ontario by the Ministry of Environment since the mid-1970s. Roughly 165,000+ fish from 86 species and 1,600+ sites were tested for Hg, with this equating to about 1.5 million database records across Ontario. Non-systematic sampling methods, while appropriate for the widely distributed biennial publication of the *Guide to Eating Ontario Sport Fish*, proves troublesome when investigating long-term spatial and temporal trends. We present here the result of applying a model developed by the USGS to standardize the sampling characteristics of the entire database to a unique length and portion type for Walleye (*Sander vitreous*) and Yellow Perch (*Perca flavescens*). Our findings show that Hg can be reliably predicted by the model for specific location-years. We are then able to use a GIS to examine spatial and temporal trends. We present our analysis results and discuss the relevance of the trends observed to date. *Keywords: Mercury, Spatial analysis, Model testing.*

DEPEW, D.C.[1], CAMPBELL, L.M.[1], and BURGESS, N.M.[2], [1]School of Environmental Studies, Queen's University, Kingston, ON, K7L 3N6; [2]Wildlife and Landscape Scientific Directorate,

Environment Canada, Mount Pearl, NL, A1N 4T3. **An Introduction to the National Fish Mercury Database and CARA Mercury Science Program.**

A substantial amount of data on mercury concentrations in freshwater fish already exists in Canada, produced by governmental agencies,universities and mercury research networks, hydro electric utilities, consultants and non-profit organizations. Under Environment Canada's Clean Air Regulatory Agenda (CARA) Mercury Science Program, we are compiling available data into a national level database for a comprehensive spatial and temporal analysis of fish mercury burdens in Canada, which will become part of a National Mercury Science Assessment Report planned for 2012. An overview of the Ecological Risk Mapping component of the CARA Mercury Science Program will be given along with a discussion of the proposed scientific outputs and integration with other CARA Mercury Science teams. *Keywords: Data storage and retrieval, Mercury, Fish.*

DEPEW, D.C., HOUBEN, A.J., OZERSKY, T., HECKY, R.E., and GUILDFORD, S.J., Department of Biology, University of Waterloo, 200 University Ave W, ON, N2L 3G1. **Some observations on the lack of Cladophora growth in Lake Simcoe.**

In recent years, a resurgence of filamentous benthic algae (e.g., Cladophora) in the Laurentian Great Lakes has been perceived as a consequence of dreissenid mussel invasion and subsequent alterations to ecosystem nutrient and energy cycling. We examined two sites in Lake Simcoe using a novel high resolution hydro-acoustic survey method to assess the presence and extent of excessive benthic algal growth on hard substratum. Despite comparable dreissenid abundance, water clarity and phosphorus concentrations to sites in the lower Great Lakes known to suffer extensive Cladophora fouling during the summer months, only trace amounts of Cladophora were found in the surveyed areas. The proximal cause for the lack of excessive Cladophora growth in Lake Simcoe remains elusive. Differences in the abiotic and biotic environment between the lower Great Lakes and Lake Simcoe will be discussed as they pertain to nuisance benthic algal development. *Keywords: Benthic flora, Lake Simcoe, Ecosystems.*

DEPINTO, J.V., VERHAMME, E.M., and REDDER, T.R., LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108. **Calibration and Diagnostic Analysis of SAGEM2, a Fine-Scale Ecosystem Model of Saginaw Bay.**

As part of a large project focused on development of an Adaptive Integrated Framework for managing the effects of multiple stressors in Saginaw Bay, Lake Huron, we have developed a fine-scale, three-dimensional linked hydrodynamic – advanced nutrient-lower food web model (SAGEM2). This model is intended to analyze the relative contributions of nutrient loads, dreissenid density and activity, and hydrometeorological forcing on ecosystem endpoints of concern. These responses include: benthic nuisance algal growth, hazardous cyanophyte blooms, formation and shoreline fouling of "muck", and production of biomass that can be transferred to the upper food web. This presentation will present the calibration of this model to the 1991-1996 data set acquired during this period of dreissenid colonization in Saginaw Bay. Diagnostics of the impacts of the stressors mentioned above indicate significant responses in terms of shift to

benthic primary production and muck formation and Microcystis blooms to both phosphorus loads and dreissenid density. *Keywords: Model studies, Dreissena, Algae.*

DERMOTT, R., MARTCHENKO, D., and JOHNSON, M.J., Great Lakes Lab Fish. Aquatic Science, Fisheries & Oceans, Burlington, ON, L7R 4A6, Canada. **Changing Benthic Fauna in the Bay of Quinte, 40 years of change.**

One goal of the Quinte Remedial Action Plan is to restore the degraded benthic community to a balanced one typical of mesotrophic areas. To verify the improved status of the community, data collected from 4 sites over 40 years were analyzed. Habitats range from the shallow upper bay(6 m), with easily disturbed sediment, to the more stable environment in the lower bay (21 m to 32 m depth) and in Lake Ontario. From 1977 -1990, the worm - chironomid community in the upper bay responded to phosphorus reduction with decreased densities and mean organism size, increased diversity and return of rare species. This accelerated after the arrival of Dreissena in 1993. Epibenthic fauna increased in the upper bay between 1986 - 2001, but decreased after arrival of Round Gobies. The lower bay responded slower but underwent a major regime change when quagga mussels replaced the glacial relic amphipod Diporeia as the dominant taxa. Non-dreissenid biomass decreased in the lower bay since 1990, but changed little in the upper bay. Densities in the upper bay responded opposite that in the lower bay (CUSUM analysis). Clustering showed the upper community remained different from the lower bay community. Since 2000, the upper bay community remained similar, but has diverted far from the typical Great Lakes community in the lower bay. *Keywords: Benthos, Ecosystem health, Remediation.*

DERMOTT, R., BONNELL, R., and BEDFORD, A., Great Lakes Lab for Fisheries Aquatic Science, Fisheries and Oceans, 867 Lakeshore Road, Burlington, ON, L7R 4A6, Canada. **Possible Factors Allowing Continued Survival of *Diporeia*. in a Lake with*Dreissena*.**

In large areas of the Great Lakes, dramatic declines of the amphipod *Diporeia* occurred soon after the arrival of *Dreissena*. The effects often were seen several kilometres offshore from expanding mussel colonies. *Dreissena polymorpha* entered Charleston Lake, a deep lake with Lake Trout in eastern Ontario, during 2001. Unlike the resulting extirpation in areas of lakes Michigan and Ontario having mussels, *Diporeia* were still abundant when resurveyed 8 years later. Stable amphipod populations at 20 and 40 m are able to survive in Charleston Lake despite being encircled by mussels on the numerous islands and shoals. We investigated causative conditions that have allowed *Diporeia* to survive in the *Dreissena* infested waters. Contributing factors considered included organic content of sediment, organic particle size, bathometry profiles, riparian composition, and lake use. *Keywords: Sediments, Zebra mussels, Amphipods.*

DEWEY, R.[1], HOWELL, T.[2], BOWEN, G.[3], BOOTY, W.[4], BISHOP, R.[5], BOUCHARD, R.[6], and SNODGRASS, W.J.[7], [1]City of Toronto, Metro Hall, 55 John Street, 27th Floor, Toronto, ON, M5V3C6; [2]Ministry of Environment, 5775 Yonge Street, 8th Floor, Toronto, ON, M2M 4J1; [3]Toronto and Region Conservation, 70 Canuck Avenue, Downsview, ON, M3K 2C5;

[4]National Water Research Institute, Environment Canada, Burlington, ON, L7R 4A6; [5]MMM Group Limited, 100 Commerce Valley Drive West, Thornhill, ON, L3T 1A1; [6]Regional Municipality of Peel, 10 Peel Centre Drive, Brampton, ON, L6T 4B9; [7]City of Toronto, Metro Hall, 55 John Street, 18th Floor, Toronto, ON, M5V 3C6. **Importance of Diffuse Sources and Direct Point Source Discharges in Lake Ontario Source Water Protection Studies.**

This paper provides a perspective on the distance off-shore that different substances are influenced by loadings from watersheds, urban runoff, and direct, mainly wastewater treatment plant effluents for representative constituents (nutrients TSS and E Coli) along the north shore of Lake Ontario for 2008. This perspective allows us to pilot the intensity of urbanization as an index in delineating urban influences as a risk to intakes for potable drinking water production. A modelling methodology was used to estimate the relative importance of the largest watersheds around the north shore of Lake Ontario (see allied paper, Bowen et al). Discharges from wastewater effluents were estimated from monitored information. For the Toronto area watersheds, estimates using the HSPF model have also been generated, particularly for E Coli. Average seasonal concentrations in the Coastal Zone forecast by a hydrodynamic modelling tool (MIKE 3) was compared to 2008 monitoring data. These assessments are used to (i) to link 'the intensity of urbanization' to risk to intakes for purposes of Source Water Protection analyses, (ii) to address constituents important operators, and (iii) to evaluate delisting criteria for the concerned AOC's. *Keywords: Monitoring, Nutrients.*

DICKINSON, W.T., RUDRA, R.P., AMILI, A., AHMED, M.M., and AHMED, S.I., School of Enginereing, University of Guelph, Guelph, OM, N1G2W1, Canada. **Trends in Winter Precipitation and Temperatures across Ontario.**

There is considerable interest and speculation regarding how and the extent to which climate change might alter the hydrologic response. Winter hydrology is of specific interest. This study was undertaken to explore trends in winter precipitation and temperatures over the past 60 years at 13 weather stations located across Ontario. Daily rainfall, snowfall and total precipitation amounts for the months of November through April provided winter rainfall, snowfall and precipitation totals. The temperature variables included the extreme daily maximum, the mean daily maximum, the extreme daily minimum, the mean daily minimum, the maximum daily mean, the minimum daily mean and the mean daily temperature. The results reveal that snowfall amounts have been decreasing and winter rainfall amounts have been increasing consistently across the province, with no consistent trend in total precipitation. Relatively few of the trend slopes were found to be significantly different from zero, as the variability in the data is extremely large and the trends generally account for less than 5 percent of the variability. Winter temperatures have increased consistently across the province. The winter temperatures are highly variable. However, many of the trend slopes were found to be significant, accounting for higher percentage of the variability. *Keywords: Temperature, Snowfall - Rainfall, Climate change, Wniter precipitation, Climatic data, Climates.*

DICKINSON, W.T., RUDRA, R.P., PATEL, P., ZHOU, J., and AHMED, S.I., School of Engineering, University of Guelph, Guelph, ON, N1G2W1, Canada. **Trends in Rainfall Extremes in Ontario.**

Recent reports relating to climate change have drawn attention to the likelihood of increases in rainfall amounts in various regions of North America, prompting interest and a need to clarify evidence relating to the nature and extent of changes in rainfall extremes in local areas. The possibility of changes in short-duration rainfall extremes is of particular interest to persons concerned about stormwater management, soil erosion and sediment yield. This paper presents results from trend and extreme value of rainfall extremes for 15, 30 and 60 minutes, and 6 and 12 hours at 15 locations across Ontario. The results reveal considerable variability in change per decade for the annual rainfall extremes (20% to +20%, most values between -5% and +5%;, no consistent positive or negative trend). Results of the monthly extreme rainfall values offer some evidence that the short-duration rainfall extremes in southern Ontario have increased in spring and fall. These increases have not had an effect on annual extreme values. Nonetheless, if indeed spring and/or fall rainfall extremes continue to increase, there may well be significant impacts on soil erosion, sediment yield and other issues. *Keywords: Variability, Climatic data, Precipitation, Climates, Rainfall extremes, Climate change.*

DIROCCO, J., MCDONALD, K., and TONINGER, R., 5 Shoreham Drive, Downsview, ON, M3N1S4. **Tommy Thompson Park: Toronto's best example of planned habitat restoration and adaptive management.**

Tommy Thompson Park, also known as the Leslie Street Spit, is a man-made peninsula in Toronto owned and managed by Toronto and Region Conservation (TRCA). TRCA has undertaken the restoration and enhancement of fish and wildlife habitat at this unique urban wilderness. Through extensive planning and consultation, a strategic Natural Area Enhancement Plan for terrestrial and aquatic habitat enhancements has been developed and is currently being implemented. General habitat improvements, as well as species specific essential habitats targeting a range of life stages for fish, herpetiles, colonial waterbirds, waterfowl, shorebirds and mammals, have been created and enhanced. Projects include spawning and nursery habitat, isolated amphibian pools, in-water and shoreline structural improvements, island creation, and coastal wetland development. A range of monitoring projects are associated with habitat restoration, from planning to implementing to adaptively managing for optimal productivity and wildlife use. Monitoring includes vegetation mapping, remote camera surveillance, amphibian, bird, mammal and fisheries surveys. Data collected show intriguing trends and document changes in the biological communities. Habitat restoration contributes to TTP as the most significant natural feature along the central Toronto waterfront. *Keywords: Monitoring, Restoration, Habitat.*

DJOUMNA, G. and LAMB, K.G., Department of Applied Mathematics, University of Waterloo, Waterloo, ON, N2L 3G1. **Turbulent and Radiative Fluxes and their Effects on Heating Lake Erie.**

Two three-dimensional numerical models, the MITgcm and ELCOM, are used to study the effects of momentum, turbulent and radiative fluxes on heating in Lake Erie using observed forcing for the year 2002. The MITgcm (MIT General Circulation Model) is an efficiently parallelized non-hydrostatic model designed for studying of the atmosphere, ocean, and climate while the ELCOM (Estuary and Lake Computer Model) is a hydrostatic lake model. At an air-sea interface, the total heat flux consists of both radiative fluxes (short- and long-wave) and turbulent fluxes (sensible and latent). Solar radiation is the primary source of energy that drives the at- mospheric and oceanic circulations. The absorption of solar energy and its transformation to heat has a profound effect on the thermal structure, and circulation pattern of lakes and oceans. An accurate parametrization of the radiative fluxes and turbulent fluxes is important for modeling physical, chemical and biological processes oceans, and lakes. The MITgcm model is used to compare various parametrization schemes for bulk transfer coefficients, the absorption of penetrative solar radiation, long-wave radiation and turbulent heat fluxes. *Keywords: Lake Erie, Air-water interfaces, Waves.*

DOBIESZ, N.E., Large Lakes Observatory, University of Minnesota Duluth, 2205 East 5th St. RLB 109, Duluth, MN, 55812.
Integrating fisheries data: addressing the challenges and creating new tools.

Management of the Laurentian Great Lakes fisheries is shared by Canada and the US, eight states, the province of Ontario, and several Native American tribes. Coordinated fisheries management activities occur through the lake committees of the Great Lakes Fishery Commission, under the Joint Strategic Plan for Management (JSP) adopted in 1981. One of the key elements of the JSP is the sharing of information between the managing agencies. Although this process enables information sharing, the newest technologies have yet to be employed to create integrated fisheries data. While computer technology has progressed since the 1980s to allow large integrated databases capable of storing many types of data, several attempts to integrate limited data sets have not been completely successful. We describe the challenges of integrating fisheries data including spatial and temporal scales, aggregation versus summarization, collection protocols and data validation, and acceptance by the fisheries management community. We examine the value of a centralized, web-based system of data acquisition, database management, decision support modeling and visualization for aiding fisheries managers. We also explore visualization tools as important ways of analyzing, viewing, and sharing data, and present new tools under development. *Keywords: Data storage and retrieval, Integrated data, Great Lakes basin, Management.*

DOBSON, T.[1] and MASSON, C.[2], [1]Michigan State University, 13 Natural Resources Bldg., East Lansing, MI, 48824-1222; [2]FreshWater Consulting, 341-2 Laird Drive, Toronto, ON, M4G 3T0.
Research Agenda for Ecosystem Health in Large Lakes: A Partnership between Biological and Human Dimensions Science.

The human dimension (HD) of fisheries management is a clear picture of the complex functions of individuals, groups, uses and satisfactions derived from fisheries-related activity. Why should fishery managers consider HD? Together with biological and ecological

information, HD is an active and direct social scientific object of study, subject to rigorous observation and description, thorough assessment, recording and documentation using primary source material. The array of HD research tools and techniques includes quantitative and qualitative data gathering, statistical and geospatial analysis. Decision-makers need to know more than catch and effort. They need to understand what fishers and stakeholders think and do regarding fishery resources. Social-economic systems inform the decision-making process in two ways: 1) Design and operation of oversight agencies, and 2) By providing critical feedback to management. This paper reports on human and ecosystem health discussions held at the 2009 IAGLR meeting. The workshop brought together scholars of diverse disciplines whose research focuses on large, freshwater aquatic systems. Here we seek to share key ideas that emerged from our analyses towards further efforts to achieve a sustainable basis for satisfactory fisheries policy and management strategies in the world's great lakes. *Keywords: Human Dimensions, Ecosystem health, Social-ecological systems.*

DOKA, S.E.[1], MINNS, C.K.[2], BAKELAAR, C.N.[1], LEISTI, K.E.[1], and CHU, C.[3], [1]Fisheries & Oceans Canada, 867 Lakeshore Rd. Box 5050, Burlington, ON, L7R 4A6; [2]University of Toronto, 25 Willcocks St., Toronto, ON, M5S 3B2; [3]Ontario Ministry of Natural Resources, Trent University, Peterborough, ON, K9J 7B8. **Predicting the production dynamics of selected fish populations in the Bay of Quinte in relation to changes in habitat quality and quantity.**

For many fish species in the Bay of Quinte, the quality and quantity of habitats, needed to complete life cycles and sustain populations, have varied considerably in response to changes in climate, water levels, eutrophication, and species invasions. Multi-stage fish population simulation models driven by estimates of suitable habitat supply were used to assess the relative impact of the various stressors over the period 1972-2008 when fish communities have been continuously assessed by a range of methods. Air and surface water temperatures increased over the study period while water levels trended lower on average. Point source phosphorus loading began decreasing in the late 1970s and decreases have continued to the present. The invasion by dreissenids brought substantial changes to the Bay of Quinte with increased water clarity, decreased algal biomass with a substantial expansion of macrophyte coverage. The model simulations showed the relative impact of the various factors. The simulated populations tracked coarse changes to the species catches in the Bay. Simulation forecasts of periods later in the 21st century indicated substantial changes in suitable habitat supply and fish production can be expected with continued climate change. *Keywords: Fish populations, Habitats, Bay of Quinte.*

DOLAN, D.M.[1], CHAPRA, S.C.[2], MACCOUX, M.J.[3], and SCHMITT-MARQUEZ, H.S.[3], [1]University of Wisconsin - Green Bay, Natural and Applied Sciences, Green Bay, WI, 54311; [2]Tufts University, Civil and Environmental Engineering, Medford, MA, 2155; [3]Univerity of Wisconsin-Green Bay, Environmental Science and Policy Program, Green Bay, WI, 54321. **Nutrient Loading Trends for Lakes Michigan, Superior and Huron.**

Total phosphorus and nitrate loads to Lake Michigan were last estimated on a lakewide basis in 1995 as part of the Mass Balance Study. Total phosphorus loads to Lakes Huron and

Superior were last reported for 1991 and comprehensive nitrate loads for these lakes have never been reported. Through a grant received from the U.S. EPA, Great Lakes National Program Office (GLNPO), an effort has been made to update phosphorus and nitrate load estimation efforts for all of the Great Lakes. A combination of modeling and data analysis has been 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. A mass balance model for phosphorus and nitrate has been used to compare projections with direct estimates from measurements obtained primarily from the mid-1970s to the present. The analysis suggests that the target phosphorus load has been consistently met for the main bodies of these lakes. However, high nutrient levels persist for Green Bay and Saginaw Bay. Components of the total loading that will be considered are point sources, tributaries, atmospheric, and unmonitored area. *Keywords: Nutrients, Mass balance, Pollution sources.*

DOLINSEK, I.J.[1], MCLAUGHLIN, R.L.[2], GRANT, J.W.A.[1], O'CONNOR, L.[3], and PRATT, T.[3], [1]Biology Department, Concordia University, Montreal, QC, H4B 1R6; [2]Department of Integrative Biology, University of Guelph, Guelph, ON, N1G 2W1; [3]Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences, Sault Ste-Marie, ON, P6A 6W4.
Movements of PIT tagged fishes among six Lake Ontario tributaries.

This three-year study quantified the degree of inter-stream movement made by 26 fish species among six adjacent streams in Lake Ontario. Fish movement at this spatial extent is potentially important to both ecological (e.g. metapopulation dynamics, responses to habitat fragmentation) and micro-evolutionary processes (e.g. gene flow). Yet the occurrence and frequency of inter-stream movement remain largely unexamined despite a rich literature addressing the movements of fishes. Fish movements were monitored using passive integrated transponder (PIT)tags. Thirteen of 26 species, and 10 of 13 species, moved between tributaries via Lake Ontario within and across a reproductive season. Proportions of marked individuals making inter-stream movements were low and varied among species within and among reproductive seasons. Most movements were made between immediately adjacent streams. Transplant experiments indicated that many fish were capable of making inter-stream movements and that reproductive homing and site fidelity probably account for the low frequencies of inter-stream movements. Fish assemblages in these Lake Ontario catchments are dynamic and exchange individuals at rates likely to be important for metapopulation dynamics and gene flow, but not for populations to respond en masse to in-stream structures that block movement. *Keywords: Fish tagging, Fish movement, Fish populations, Fish behavior.*

DOLSON, R.[1], METCALFE, B.W.[2], and LA ROSE, J.K.L.[1], [1]Ontario Ministry of Natural Resources, Lake Simcoe Fisheries Assessment Unit, 26465 York Rd 18, Sutton West, ON, L0E 1R0; [2]Ontario Ministry of Natural Resources, Aquatic Research and Development Section, Glenora Fisheries Station, R.R. #4, 41 Hatchery Lane, Picton, ON, K0K 2T0.
Long-Term changes in the Biodiversity of the Nearshore Fish Community in Lake Simcoe, Ontario.

Native species biodiversity is recognized as a key feature of healthy ecosystems. Small bodied fishes enhabiting the nearshore zone comprise a significant portion of the overall fish

diversity in Lake Simcoe, Ontario. In 2006, we developed an assessment program to monitor the biodiversity of small bodied fishes in the nearshore zone of Lake Simcoe. This project seeks to assess the current state of small fish diversity, as well as trends in diversity through time. We sampled the nearshore fish community between 2007 and 2009 at reference sites along south and west shores of the lake. Results suggest that the nearshore small fish community was numerically dominated by members of the Cyprinidae family, accounting for more than 90% of the total catch. We also compared the current state of nearshore diversity between two time periods using data collected 20 years prior. Preliminary results suggest that while species richness was similar to that observed in the past, indices of evenness and diversity have declined. The abundance of some key species has also changed over the past two decades. *Keywords: Biodiversity, Fish populations, Littoral zone.*

DOMYSHEVA, V.M. and SAKIRKO, M.V., Ulan-Batorskaya, 3, Ulan-Batorskaya, 3, Irkutsk, IB, 664033, Russia. **Estimation of the modern hydrochemical state of Lake Baikal.**

Monitoring of the chemical composition of the water of Lake Baikal (1999-2009) has shown that the concentration of biogenic elements increases with depth and does not exceed 1.9 mg Si/l for silicon, 0.14 mg N/l for nitrates and 0.020 mg P/l for phosphates. Seasonal variations of the content of biogenic elements occur mainly in the upper 300 m layer. The unique mechanism of renewal of deep water in spring and autumn leads to the decrease of their concentrations in the 100-m near-bottom layer. The content of dissolved oxygen is 9-14 mg/l, the value of oxygen saturation of the water of near-bottom layer does not decrease lower than 70%. The concentration of biogenic elements in the deep water of the pelagic zone of the lake, which is not undergone seasonal variations, is practically constant during the last 60 years. The concentrations of Na^+, Ca^{2+}, Mg^{2+}, K^+, HCO_3-, SO_4^{2-}, Cl^- in the water of Lake Baikal are stable. The constancy of the content is caused by insignificance of the annual water sink of the tributaries in comparison with the volume of the water mass of the lake, as well as intensive water exchange in the lake. *Keywords: Geochemistry, Monitoring, Water quality.*

DONNELLY, P.B. and PEACH, G., Lake Huron Coastal Centre, P.O. Box 178, Blyth, ON, N0M 1H0. **A Decade of Lake Huron Coastal Stewardship.**

The Lake Huron Coastal Centre has been fostering sustainable behaviour towards Lake Huron's coastal ecosystem for over 10 years. Serving the Ontario side of the lake roughly from Tobermory to Sarnia, the Centre's work is science-based which provides a sound foundation from which to make management and stewardship recommendations. Being a not-for-profit environmental organization also provides opportunities not available to government agencies. It acts as an advocate for the health of the coastal ecosystem; regardless of specific programs and local agendas. Their focus on grass-roots stewardship provides some stability and resiliency in the face of changing climates and changing political directions.The Coastal Centre's toolkit is extensive as it uses a variety of techniques designed to engage residents through education and awareness. Conferences and workshops, such as the biennial conference titled "Is the Coast Clear?" have developed into significant local events attracting researchers, politicians, cottagers and government technical staff who share coastal problems and discuss solutions. Curriculum

resources kits have also been successfully developed for elementary schools, designed to bring coastal issues into the classroom. Climate change, biodiversity, water quality and coastal processes are the Centre's primary topics. *Keywords: Coastal ecosystems, Coastal community, Biodiversity, Social marketing, Lake Huron, Education.*

DOROSTKAR, A.[1], BOEGMAN, L.[1], DIAMESSIS, P.J.[2], and POLLARD, A.[3], [1]Department of Civil Engineering, Queen's University, Kingston, ON; [2]School of Civil and Environmental Engineering, Cornell University, Ithaca, NY, US; [3]Department of Mechanical Engineering, Queen's University, Kingston, ON, Canada.
Comparison of hydrostatic and non-hydrostatic modeling of internal wave fields in Cayuga Lake.

The 3D high-resolution simulation of lakes with diameter > 1 km has not been performed, with sufficient resolution to resolve small-scale nonhydrostatic processes (e.g. high-frequency nonlinear internal waves), due to the computational requirements. In this research, the parallel 3D MITgcm is applied to simulate the multi-scale nonhydrostatic response of the medium sized Cayuga Lake to the applied surface wind forcing. The model is validated on a 400x400 m grid against field observations over an 11 day simulation. The phase and amplitude of the basin-scale seiche dynamics were well modeled and the r.m.s. error between model results and simulations was minimized with a Smagorinsky scheme for the horizontal eddy viscosity and a constant vertical eddy viscosity of 10^{-3} m/s^2 with a polynomial Equation of State. Using the calibrated model parameters, higher resolution hydrostatic and nonhydrostatic simulations were performed on a fine 39x39 m grid. Preliminary nonhydrostatic simulations resolve progressive nonlinear internal waves in the 10^{-4} Hz frequency band, but were unable to simulate shear instabilities, which have ~ 20 m wavelengths, well below model resolution. The MITgcm thus reproduces the spectrum of internal waves in Cayuga Lake ranging from the basin-scale to the nonhydrostatic features. *Keywords: Hydrodynamic model, Cayuga Lake, Computer models, MITgcm, Internal waves.*

DOUCETTE, J.S.[1], VILLARD, P.V.[1], and THOMAS, J.S.[2], [1]Geomorphic Solutions, 141 Brunel Road, Mississauga, ON, L4Z 1X3; [2]Credit Valley Conservation, 1255 Old Derry Road, Mississauga, ON, L5N6R4.
The Dynamics of a Barrier Bay Outlet, Rattray Marsh, Mississauga, Lake Ontario.

Rattray Marsh is a coastal wetland separated from Lake Ontario by a barrier spit. Sheridan Creek which flows into Rattray Marsh has a densely urbanized watershed lacking in stormwater control. Storm flows are extremely flashy. Water levels in the marsh are controlled by the opening and closing of the mouth and the relative water level in Lake Ontario. Knowledge of the processes governing the opening and closing of the barrier is important to be able to evaluate potential impacts due to stormwater management practices, different lake water level management scenarios and climate change. Periodic observations were made of the outlet for over 2 years. Observations consisted of photographs, and on 6 occasions the detailed morphology of the outlet was measured using an RTK GPS with accuracy on the order of centimeters. Seasonal conditions were identified. The opening and closing of the outlet was evaluated in context of discharge from Sheridan Creek, Lake Ontario water levels, local wind

speed and direction and estimated wave heights. *Keywords: Monitoring, Coastal processes, Lake Ontario.*

DRAKE, A.[1], MANDRAK, N.E.[2], and HARVEY, H.H.[1], [1]Department of Ecology and Evolutionary Biology, University of Toronto, Toronto, ON, M5S3B2; [2]Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, Burlington, ON, L7R 4A6.
From Incidental Harvest to Release: 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 Great Lakes basin (GLB). Therefore, preventing further AIS introductions is of utmost importance. The commercial baitfish industry in Ontario is one of several secondary pathways that have the potential to transfer AIS within and beyond the GLB. 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 the end-user; and, 4) AIS release by the end-user. Although the overall probability of AIS introduction was low, the prevalence of end-user release suggests that this pathway is an important secondary transfer vector contingent upon the relative abundance of AIS within donor ecosystems, commercial harvests and retail facilities. *Keywords: Biological invasions, Risk assessment, Fisheries.*

DRYFHOUT-CLARK, H.[1], BLANCHARD, P.[2], BACKUS, S.[3], WONG, H.[3], ECKLEY, C.S.[4], and ZHANG, L.[2], [1]Environment Canada, 6248 Eighth Line, Egbert, ON, L0L 1N0, Canada; [2]Environment Canada, 4905 Dufferin Street, Toronto, ON, M3H 5T4, Canada; [3]Environment Canada, 867 Lakeshore Rd, Burlington, ON, L7S 1A1, Canada; [4]Environment Canada, 401 Burrard St, Vancouver, BC, V6C 3L5, Canada.
Spatial and temporal trends of airborne trace metals in the Great Lakes Basin (1988 to 2005).

Measurements of trace metals on particulate matter (<10 µm) were made at three locations within the Great Lakes basin in southern Ontario as part of the Integrated Atmospheric Deposition Network (IADN) since 1988. This dataset was used to address the following objectives: 1) quantify anthropogenic enrichment; 2) characterize spatial and temporal trends; 3) identify potential sources; and 4) calculate dry deposition loads for Lake Ontario and Erie. The results showed that the degree of enrichment varied between the different metals, for example: Cd>As>Pb>Se. Overall, metal concentrations were slightly higher at the two locations nearer anthropogenic activity (Egbert and Point Petre) than at the more remote site (Burnt Island). However, the remote site did have higher concentrations of Cu and Ni, which back trajectory analysis suggested may have originated from regional mining activity. Temporal trend analysis identified a decrease in Pb and an increase in Se concentrations since the 1990s. Calculating trace metal dry deposition using a V_d of 0.2 cm/s resulted in fluxes that were <25% of wet

deposition. However, accounting for the occurrence of some elements associated with larger particles resulted in an increase in dry depositional fluxes, which were larger than wet depositional fluxes during summer months. *Keywords: Airsheds, IADN, Metals.*

DSOUZA, N.A.[1], SAXTON, M.A.[2], BULLERJAHN, G.S.[1], WILHELM, S.W.[2], and MCKAY, R.M.L.[1], [1]Department of Biological Sciences, Bowling Green State University, Bowling Green, OH, 43403; [2]Department of Microbiology, The University of Tennessee, Knoxville, TN, 37996. **Psychrophilic Diatoms in Ice-Covered Lake Erie.**

Lake wide surveys conducted in winter 2008 and 2009 documented high phytoplankton biomass dominated by a nutrient-replete, low-light adapted, filamentous centric diatom, *Aulacoseira islandica* (O. Müller) Simonsen. Visible *Aulacoseira* accumulations were present at levels exceeding Chl-*a* concentrations observed in summer and spring. Other taxa included *Stephanodiscus* spp., which accounted for ~20% of the microplankton. *Fragilaria* spp., *Asterionella* spp. and *Cyclotella* spp. were also observed. Total light-saturated winter primary production attributed to the microplankton-dominated assemblage ranged from ~2-4 g C/g Chl a/h at most central basin sites. Photosynthesis vs. irradiance (PE) curves yielded average Ek values of 25-30 µmol photons m^{-2} s^{-1}, suggestive of a low light-adapted community. A fluorophore targeting biogenic silica deposition was applied identifying actively growing cells and a modified SEM approach detailed unusual associations between diatoms as well as non-uniform bacterial colonization on the diatoms. This physiologically robust assemblage of psychrophilic diatoms in Lake Erie represents an important, yet to date poorly documented, phytoplankton population that plays an important role in the annual carbon budgets of this large lake. *Keywords: Lake Erie, Ice, Diatoms.*

DUNN, G.[1], MCKAGUE, K.[2], RANDELL, D.[3], LOCKE, B.[1], SWEENEY, S.[2], and GILBERT, J.M.[1], [1]Lake Erie Management Unit, MNR, 659 Exeter Rd., London, ON, N6E 1L3; [2]Ontario Ministry of Agriculture, Food and Rural Affairs, 1 Stone Rd. West, Guelph, ON, N1G 4Y2; [3]Ducks Unlimited Ca., Chatham, ON. **A Successful Multi-partnership Initiative Toward Restoring Rondeau Bay's Ecological Integrity.**

Rondeau Bay is an area of focus for the Lake Erie Management Plan (LAMP) and the Canada/Ontario Agreement Respecting the Great Lakes (COA). The Bay contains one of the few remaining, hydrologically intact, large coastal wetland systems on Lake Erie. It is recognized as a major fish production area and an important refuge for a number of Species at Risk (SAR). Results of a two year COA funded ecological assessment revealed severe nutrient management issues within this small agriculturally based watershed with direct impacts to biodiversity and SAR. A restoration strategy was subsequently developed with concrete initiatives and set targets. As a result the Restoration of Rondeau Bay's Ecological Integrity Project (The Rondeau Project) was commenced in 2007. The Project is lead by the Lake Erie Management Unit (MNR) with strong collaborative partnerships between Federal, Provincial, and Municipal agencies, NGO's, private landowners, and community organizations. To date a number of restoration initiatives have been completed including the development of nutrient reduction ponds, in-field improvements, buffer strips, wetland restorations, invasive species control, public outreach and

education programs. A large number of projects have been planned for 2010. A summary of the Rondeau Project and successes to date will be discussed. *Keywords: Remediation, Watersheds, Nutrients.*

DUSSAULT, E.B., SHERRY, J.P., MCMASTER, M.E., PARROTT, J.L., HEWITT, L.M., and BROWN, S.B., Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Health Status of Wild Fish from the St. Lawrence River (Cornwall) Area of Concern - 1. Biological Effects.**

Environment Canada has conducted studies evaluating endocrine function and overall fish health to readdress fish health issues in the Canadian Areas of Concern. The present study reports on brown bullhead (*Ictalurus nebulosus*) and yellow perch (*Perca flavescens*) collected from the St. Lawrence Area of Concern (Cornwall). Fish health assessments used estimates of age structure, energy storage and energy utilization. Endocrine assessments included plasma concentrations of vitellogenin and major steroids, *in vitro* steroid synthesis, and thyroid status. Liver EROD activity was also measured. The gonads were evaluated histologically for developmental stage, and liver samples were collected and evaluated for the presence of tumors. Exposure to endocrine disruptors was also investigated by deployment of semi-permeable membrane devices (SPMDs), and pooled liver tissues, extracted and analyzed for the presence of endocrine active compounds. Preliminary results indicate significant differences between exposed and reference sites for several variables, including decreased plasma vitellogenin and decreased *in vitro* steroid synthesis in females collected at the exposed site. Those differences do not appear to be attributed to the presence of endocrine active compounds in the water column. *Keywords: PCBs, Lake Ontario, Areas of Concern, St. Lawrence River.*

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. **Health Status of Wild Fish from the St. Lawrence River (Cornwall) Area of Concern - 2. PCB body burden and hydroxylated metabolites in fish plasma.**

The St Lawrence (Cornwall) Area of Concern has suffered from degradation due to contamination from agricultural, industrial and municipal sources, as well as habitat destruction, nutrient enrichment and introduction of exotic species. Amongst the contaminants of concern, sediment contamination by historical sources of PCBs is thought to pose a potential threat. Studies have suggested that hydroxylated PCBs (OH-PCBs), by-products of microbial and biological degradation, could also interact with fish thyroid function, and have effects on wild fish populations. However, few studies to date have investigated the environmental exposure and effects of these metabolites. The present study investigated the environmental occurrence of PCBs and hydroxylated metabolites in brown bullhead (*Ictalurus nebulosus*) from the St. Lawrence River (Cornwall) Area of Concern. PCB congener body burdens were determined and plasma OH-PCBs concentrations were quantified using GC-high resolution mass spectrometry. These data will be compared and contrasted with other sites in the Great lakes, as well as measurements of fish health, in the context of potential environmental health effects. *Keywords: PCBs, Lake Ontario, Areas of Concern, St. Lawrence River.*

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EASTLING, P.M. and HORNBUCKLE, K.C., 4114 Seamans Center for the Engineering Arts and Sciences, Iowa City, IA, 52245. **Polychlorinated Biphynols in Cedar Rapids Flood Sediment.**

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), and analyzed using GC/ECD, GC/MSD and GC/MS/MS. This presentation focuses on the PCB analysis. *Keywords: Sediment transport, Flood, PCBs.*

EDGE, T.A.[1], KHAN, I.[1], LOUGHBOROUGH, A.[1], BOUCHARD, R.[2], LOCAS, A.[3], MOORE, L.[4], NEUMANN, N.[5], PAYMENT, P.[3], YERUBANDI, R.[1], and WATSON, S.[1], [1]867 Lakeshore Road, Burlington, ON, L7R 4A6, Canada; [2]Region of Peel, Mississauga, ON; [3]Institut national de recherche scientific, Laval, QU; [4]Ontario Clean Water Agency, Toronto, ON; [5]Univrsity of Alberta, Edmonton, AB. **Occurrence of fecal indicator bacteria and waterborne pathogens in Lake Ontario source water of several Drinking Water Treatment Plants.**

Field studies were begun by The Collaborative Study to Protect Lake Ontario Drinking Water in 2007 to investigate the occurrence of waterborne pathogens in the source water of drinking water treatment plants on Lake Ontario. A pilot study is being conducted at several Water Treatment Plants near the mouth of the Credit River to investigate the occurrence of fecal indicator bacteria and waterborne pathogens (e.g. Campylobacter, Cryptosporidium, Giardia, culturable enteric viruses). The waterborne pathogen pilot study has been embedded in a water research effort characterizing water movements, water temperature profiles, and water quality aspects such as turbidity, nutrients, dissolved and particulate forms of carbon, phytoplankton, chlorophyll a, algal toxins, and taste and odour compounds. There has been a relatively low level of contamination from fecal indicator bacteria and waterborne pathogens in offshore source water for the Water Treatment Plants to date. However, all pathogens have been detected at times, and E. coli numbers have reached as high as 222 cfu/100mL in surface water 2 km offshore. Analyses are ongoing to investigate the nature of waterborne pathogen contamination events at offshore drinking water intakes. *Keywords: Drinking water, Water quality, Microbiological studies.*

EDWARDS, W.J.[1], ATKINSON, J.F.[2], BOYER, G.[3], LEWIS, T.[4], MAKAREWICZ, J.[4], and PENNUTO, C.[5], [1]Department of Biology, Niagara University, Lewiston, NY, 14109; [2]Deparment of Civil, Structural and Environmental Engineering, University at Buffalo, Buffalo, NY, 14260; [3]Department of Biochemistry, SUNY College of Environmental Science and Forestry, Syracuse, NY, 13210; [4]Department of Evnironmental Science and Biology, SUNY Brockport, Brockport, NY, 14420; [5]Department of Biology, Buffalo State College, Buffalo, NY, 14222.
 Lake Ontario Nearshore Nutrient Transport Study (LONNS): upwelling in the nearshore region.

The Lake Ontario Nearshore Nutrient Transport Study (LONNS) was implemented 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, water clarity increased and nuisance blooms of Cladophora have become important. We combine a hydrodynamic model of Lake Ontario with in situ measurements of water velocity in the nearshore of Lake Ontario. Water velocity was measured using an Acoustic Doppler Velocimeter and concurrent measurements were taken of temperature, phytoplankton (fluoroprobe), nutrients, and turbidity across a series of transect perpendicular to the shore around Oak Orchard Creek and the Rochester Embayment. The water flow in this region is typically dominated by along shore currents. However, the hydrodynamic model predicts strong upwelling events, which were confirmed by field measurements. We assess the importance of upwelling events in the nearshore nutrient region on nearshore surface flows and test modeled results versus measured in situ data. *Keywords: Hydrodynamic model, Lake Ontario, Water currents.*

EFFLER, S.W.[1], STRAIT, C.M.[1], PERKINS, M.G.[1], and LESHKEVICH, G.A.[2], [1]P.O. Box 506, Syracuse, NY, 13214; [2]4840 S. State Road, Ann Arbor, MI, 48105.
 Patterns of Light Absorption in Lake Ontario.

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_Φ), and non-algal particles (NAP; a_{NAP}) were determined for near-surface waters of Lake Ontario in pelagic and near-shore (off Oswego) areas for samples collected in 2007, 2008 and 2009. Absorption spectra were obtained on filtrate (0.2 μm pore size) for CDOM, and filters for phytoplankton and NAP (0.7 μm; before and after bleaching). Exponential decreases with increasing wavelength (400-700 nm range) for a_{CDOM} and a_{NAP}, and bimodal patterns for a_Φ, are reported. The dependency of a_Φ on chlorophyll a is evaluated. Substantial spatial and temporal differences in the magnitude of the sum of the three components and their relative contributions to overall a are documented. a_{CDOM} was the largest component in the blue wavelengths, followed by a_Φ. The implications of the observations for remote sensing will be described.

ENQUIST, P., BAUTZ, C.R., and WILSON, R., 224 S. Michigan Ave, Chicago, IL, 60604, USA.
 The Great Lakes and St. Lawrence Region: Achieving a Sustainable Vision for this New Century.

The Great Lakes and St. Lawrence River Region holds bi-national and global importance as the supplier of 20 percent of the world's fresh water. In addition, this region has a rich and diverse landscape, key urban centers, productive farmlands, highly ranked educational institutions, and established manufacturing centers. Despite the region's importance, it faces critical environmental and economic issues. There is a great need for a comprehensive and bi-national vision that protects and restores this valuable water resource and guides the industries and cities within the watershed towards sustainability. Skidmore, Owings & Merrill's Chicago office has been working with several key stakeholders to develop a vision document titled "Recognizing the Challenge: The Need for a 100-year Vision for the Great Lakes and St. Lawrence River Region." The draft aims to begin a bi-national dialogue that will identify strategies for city development, water conservation, transportation systems, energy production, tourism and recreation, and agriculture. It is a draft that encourages all people who touch these waters to engage in conversation, enrich the dialogue, and help bring the vision into action. *Keywords: Global warming, Vision, Outreach, Future development, Development impact on Great Lakes.*

EVANS, D.O.[1], RENNIE, M.D.[2], WINTER, J.G.[3], YOUNG, J.D.[3], LA ROSE, J.[4], BARTON, D.R.[5], NORTH, R.[6], and MAZUMDER, A.[7], [1]Ministry of Natural Resources, Trent University, Peterborough, ON, K9J 7B8; [2]Environmental and Life Sciences Program, Trent University, Peterborough, ON, K9J 7B8; [3]Ontario Ministry of Environment, 125 Resores Road, Toronto, ON, M9P 3V6; [4]Lake Simcoe Fisheries Assessment Unit, 26465 Hedge Road, Sutton West, ON, L0E 1R0; [5]Department of Biology, University of Waterloo, Waterloo, ON, N2L 3G1; [6]Department of Chemistry, Trent University, Peterborough, ON, K9J 7B8; [7]Water and Aquatic Research Program, University of Victoria, Victoria, BC, V8W 4N5.
Foodweb Structure and Phosphorus Cycling in Lake Simcoe: Ecosystem Integration of Nutrient Enrichment, Species Invasions and Alteration of Predator Prey Dynamics.

Lake Simcoe has long been subjected to nutrient, sediment and contaminant loadings, and more recently to invading species, intensive fishing, fish stocking and climate change. We provide a synthesis and integration of long-term monitoring data across trophic levels with reference to top-down and bottom up food web processes. Phosphorus loading exceeded 100 t/yr during the 1970s, declined in the1980s and since 1998 has varied between 53 and 77 t/yr. Ice-free mean chlorophyll a and total phosphorus concentrations declined during the 1980s, but have not trended up or down since 1990. Food web changes since 1990, however, have been dramatic: natural recruitment of lake trout ceased beginning in the 1980s, lake herring and rainbow smelt suffered sequential recruitment failure in the presence of intensive lake trout stocking and both Dreissena polymorpha and Bythotrephes longimanus became established in the mid 1990s. Water quality improved during the late 1990s with a parallel partial recovery of cold-water fish, dramatic changes in benthic invertebrate production, and transformation of the phytoplankton and zooplankton communities. While bottom up controls are important, a trophic cascade model suggests that top down effects, yet to be considered in nutrient management strategies, have also played a significant role. *Keywords: Lake Simcoe, Food web, Water quality, Trophic cascade, Invasive species.*

FAHNENSTIEL, G.[1], POTHOVEN, S.[1], and KLARER, D.[2], [1]Lake Michigan Field St./GLERL, Muskegon, MI, 49441; [2]Old Woman Creek/NERR, Huron, OH, 44839. **Phytoplankton abundance, composition and primary production along a nearshore/offshore transect in southeastern Lake Michigan, 2007-09.**

As part of NOAA/ GLERL's long term monitoring program three stations in southern Lake Michigan have been sampled on a bi-weekly basis from March- December, 2007-2009. These three stations were located along a transect from Muskegon Pier to the offshore region (M15, M45, and M110). Sampling at these stations 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) along the transect. The Great Lakes Production model (similar to Fee model) was used to estimate phytoplankton primary production. Significant differences in all measured parameters were noted along the transect. Moreover, during the past twenty-five years significant changes in phytoplankton abundance, composition and areal primary production have been observed in this region with the most significant changes occurring in the last five years due to the filtering activities of dreissinid mussels. *Keywords: Algae, Photosynthesis, Diatoms.*

FIELD, L., MACPHERSON, G., HAWKINS, S., ST. JOHN, M., and BACH., C., Toronto and Region Conservation Authority, 5 Shoreham Drive, Downsview, ON, M3N 1S4. **The Toronto Waterfront: An Integrated Management and Restoration Approach.**

Historic degradation of the shoreline of the Greater Toronto Area led to substantive loss of aquatic habitat, which in turn was a driver for the designation of Toronto & Region as an Area of Concern in 1987. This presentation will provide an overview of the Toronto & Region Area of Concern and Remedial Action Plan, as well as outline the implementation of shoreline management initiatives on the Toronto Waterfront and integrated bio-physical approach to shoreline management that have application throughout the Great Lakes basin. The formation of Aquatic Habitat Toronto as a consensus based organization addressing aquatic habitat development on the Toronto Waterfront will also be discussed. *Keywords: Lake Ontario, Coastal ecosystems, Habitats.*

FORRESTER, L.[1], MOLOT, L.[1], and WATSON, S.B.[2], [1]Faculty of Environmental Studies, Uork University, Toronto, ON, M3J 1P3, Canada; [2]Environment Canada, CCIW 867 Lakeshore Rd, Burlington, ON, L7R 4A6. **Blooms in the Bay: do iron and light affect microcystin levels in *Microcystis aeruginosa*?**

There has been a marked shift in phytoplankton biomass and composition in the Bay of Quinte, following nutrient reduction and the invasion of non native species such as dreissenids. A disturbing increase in severe late-summer cyanobacteria blooms in the Bay has been accompanied by high levels of hepatotoxic microcystins (MCs). Species of Microcystis (M. aeruginosa, M. wesenbergii, M. viridis, M. flos-aquae) often dominate these blooms, and are suspected as major sources of MC, but our previous data show significant interannual variability

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in bloom severity and MC content. Thus their potential risks to human and aquatic health remain unpredictable and the factors influencing their occurrence and toxicity remain largely unresolved. We addressed this important issue by investigating the role of light and iron (Fe) on growth and toxicity of three M. aeruginosa strains, using combined lab and field work. Results showed marked differences among the Microcystis strains in growth and toxicity at different Fe and light levels. Field observations showed only very weak correlations between particulate MC, light extinction and total dissolved Fe. This suggests that field populations contained a mix of Microcystis strains, that other factors regulate MC production, or that total dissolved Fe is not a good measure of available Fe. *Keywords: Taste odour, Toxins, Cyanobacteria, Bay of Quinte.*

FRENCH, R.P., French Planning Services, RR2 1016 Holiday Park Drive, Bracebridge, ON, P1L 1W9, Canada. **Engaging People and Partnerships through Collaboration.**

Lake Huron-Georgian Bay Watershed - A Canadian Framework for Community Action. The Lake Huron Framework is a Canadian approach to recognize current efforts and engage partners across the Lake Huron Watershed. It was created based on the principles of Community Based Social Marketing (CBSM) and through the collaborative efforts of Environment Canada, Ontario Ministry of Natural Resources, Ontario Ministry of the Environment, Ontario Ministry of Agriculture, Food and Rural Affairs, conservation authorities and municipal agencies. Its premise is to put in place a community based approach to engage and inform everyone so that they will participate and become involved in improving the health of Lake Huron. Many projects are now in place under the umbrella of the Lake Huron Framework, including annual Lake Huron Youth Summits, watershed initiatives, and other pilot projects. *Keywords: Policy making, Lake Huron, Public education.*

FULLER, M.M., 680 Plains Rd West, Burlington, ON, L8N 3H8, Canada. **Successful Management of the Invasive Species the Common Carp (*Cyprinus carpio*) in the Restoration of Cootes Paradise, Hamilton, Ontario, Canada.**

Cootes Paradise, located in Hamilton, Ontario, Canada was once a highly functional freshwater coastal wetland. However, a combination of decreased water quality and the introduction of invasive species has compromised the biological integrity of this marsh. Despite this, it remains one of the best sites available to marsh-spawning fish species in western Lake Ontario and at 310 ha it is also one of the largest. Cootes Paradise is under the management of Royal Botanical Gardens (RBG) and the target of an innovative restoration effort, Project Paradise, of which the main focus is the removal of the invasive species the Common Carp (*Cyprinus carpio*). This is accomplished through a two-way fishway structure located at the connection between Cootes Paradise and Hamilton Harbour. The fishway prevents the movement of the common carp into the marsh, while allowing the passage of native spawning fish. With the installation of this structure, RBG has been able to exclude approximately 95% of the carp from Cootes Paradise, resulting in a decrease in carp biomass from 800 kg/ha to 57 kg/ha and a corresponding increase in water clarity, emergent and submergent plant growth and fish species diversity. Already proven to be successful, this project will continue with the ultimate goal of

restoring biological function to Cootes Paradise. *Keywords: Coastal wetlands, Remediation, Carp.*

GABRIEL, T.A., Ohio Sea Grant, OSU Extension, 28728 Wolf Rd, Bay Village, OH, 44140. **Effective Lake Erie Education and Outreach: Aquatic Visitors Center at Put-in-Bay, OH.**

The Aquatic Visitors Center at Put-in-Bay, OH is managed by Ohio Sea Grant and made possible through a partnership with the Ohio Department of Natural Resources, Division of Wildlife. Once a state fish hatchery, the facility has been renovated to serve as an interactive educational facility for the thousands of tourists that visit South Bass Island every summer. Educational topics include historical hatchery operations, Lake Erie ecology, current Lake Erie research, and the Lake Erie Sport Fisheries. The goal of the Aquatic Visitors Center is to effectively educate the public on key Lake Erie issues while providing an exciting, family friendly vacation stop. The facility was managed by Ohio Sea Grant for the first time in 2009, and over the course of the season over 12,000 individuals were educated. *Keywords: Environmental education, Lake Erie, Fisheries.*

GAMBLE, A.E.[1], HRABIK, T.R.[1], YULE, D.L.[2], and STOCKWELL, J.D.[3], [1]Biology Department, University of Minnesota Duluth, Duluth, MN, 55812; [2]Lake Superior Biological Station, 2800 Lakeshore Drive, Ashland, WI, 54806; [3]Gulf of Maine Research Institute, 350 Commercial Street, Portland, ME, 4101. **Nearshore-offshore linkages in Lake Superior: potential management implications.**

We use analysis of fish stomach contents to describe Lake Superior nearshore and offshore food web linkages. Analysis of over 10,000 diets from 16 species indicates that both nearshore and offshore, native Lake Superior fish species appear to rely upon a relatively few number of lower trophic level components. Our findings indicate that macroinvertebrates lie at the heart of each food web. In both habitats, benthic fish species tended to have a more diverse diet (averaging between 2-4 prey species), whereas planktivorous and piscivorous fish species diets were less diverse (averaging between 0-2 prey species). Mysis relicta was the primary prey item for the majority of offshore fish species (kiyi, deepwater sculpin, and small siscowet). Cisco consumed calanoid copepods, but Bythotrephes was also a primary diet component in late summer and fall. Diporeia hoyi were the primary prey items for fish species found in shallower offshore areas and most nearshore areas (i.e., slimy sculpin, spoonhead sculpin, burbot, lake whitefish, rainbow smelt, and nearshore deepwater sculpin). We hypothesize that Mysis and Diporeia are keystone species in the Lake Superior food web, both nearshore and offshore, and that changes in Mysis or Diporeia populations would have a significant impact on multiple fish species. *Keywords: Macroinvertebrates, Lake Superior, Fish diets.*

GANNON, J.E., International Joint Commission, 100 Ouellette Ave., 8th Fl, Windsor, ON, N9A 6T3. **How AOCs and RAPs evolved and what is their future?**

THe IJC Great Lakes Water Quality Board in 1973 identified Areas of Concern where Great Lakes Water Quality Agreement objectives were not being met. Class A AOCs were deemed "severely polluted" and Class B AOCs "polluted. In 1983, the WQB issued a report on status and cleanup of Class A AOCs and in 1985 attempted to do so for Class B AOCs, but there were insufficient data to do so. To infuse new energy and resources into the restoration of AOCs, the WQB introduced Remedial Action Plans (RAPs) that were subsequently incorporated in the 1987 Agreement revision by Protocol. The WQB then conducted the "How Clean is Clean?" project to develop listing/delisting criteria, whereby the 14 Beneficial Use Impairments (BUIs)were initially created in a 1986 IAGLR symposium and also included in the Agreement. To date, only four AOCs have been delisted, all of them geographically small with few pollution sources. AOCs slated for delisting soon are also small. I argue that the large AOCs (bays, connecting waterways and large urban centers) will never be delisted using existing criteria. A new pardigm is necessary that is based on adaptive management for the large AOCs. In addition, a sustainablity protocol is required for all AOCs, including the delisted ones, to guard against backsliding and to detect emerging issues. *Keywords: Great Lakes basin, Environmental policy, Water quality.*

GANNON, J.E., International Joint Commission, 100 Ouellette Ave., 8th Fl, Windsor, ON, N9A 6T3. **Towards Great Lakes Chemical, Physical and Biological Integrity.**

The International Joint Commission in its advice to governments on review of the Great Lakes Water Quality Agreement(IJC, 2006) stated that the purpose the the Agreement is still a laudable and contemporary beacon for binational cooperation in restoring and maintaining the waters of the Great Lakes basin ecosystem. The IJC further noted that the current Agreement no longer is a driver for programs and actions, so the Commission welcomed the government's announcement (6/09) that they were committed to updating the Agreement. The IJC Agreement advisory boards for the past several years have been conducting work and developing reports and advice related to the review and updating of the Agreement. Key aspects of this advice relate to inclusion of nearshore water and habitat quality and improved linking of watershed and lake institutions for research, monitoring, management and policy. Another key message has been to strive for adaptive management rather than the rigid procedures in the current Agreement that are insufficiently responsive to emerging issues (e.g., invasive species, climate change, etc.) to which the current Agreement is silent. New approaches to coherence and accountability in an adaptive management framework need to be developed in an updated and revised Agreement to replace out-of-date provisions. *Keywords: Environmental policy, Ecosystem health, Great Lakes basin.*

GARREAU, D.M., BAULCH, H.M., and DILLON, P.J., 1600 West Bank Dr., Peterborough, ON, K9J 7B8. **Sediment Phosphorus Fractions of Lake Simcoe Tributaries.**

Phosphorus (P) is frequently the limiting nutrient for algal productivity in Canadian freshwaters. In streams, large amounts of P can be stored in sediments. Depending on sediment geochemistry and stream water chemistry, sediments may either sequester or release P. In this study, we characterized the concentrations of the key forms of P stored in the sediments of 12

tributaries of Lake Simcoe. Concentrations of total P ranged widely, from 49-251 mg/kg. The highest concentrations of total P were observed in the Talbot > East Holland > Maskinonge Rivers which drain predominantly agricultural areas as well as urban areas. Inorganic P was the dominant species in all tributaries during both spring and fall, constituting 63-92% of the sediment total P. Apatite constituted the bulk of the inorganic P fraction (76-100% of inorganic P, 64-89% of total P). The low bioavailability of apatite P, when contrasted to other forms of sediment P, indicates that although a large mass of P may be stored in tributary sediments, much of this P is not readily available to biota. Further, our data suggest that reactions between sediments and overlying water may contribute to P removal from the water column, although more research on this topic is proposed. *Keywords: Lake Simcoe, Phosphorus, Eutrophication, Sediment, Geochemistry.*

GAZENDAM, E.[1], <u>GHARABAGHI, B.</u>[1], JONES, C.[2], WHITELEY, H.[1], JOOSSE, P.[3], and ROBERTS, P.[3], [1]University of Guelph, School of Engineering, Guelph, ON, N1G 2W1; [2]Ontario Ministry of Environment, Dorset Environmental Science Centre, Dorset, ON, P0A 1E0; [3]Ontario Ministry of Agriculture, Food and Rural Affairs, Guelph, ON, N1G 4Y2. **Evaluation of the QHEI as a planning and design tool for restoration of rural Ontario waterways.**

The Great Lakes and their tributaries are precious resources that require protection for future generations. The Qualitative Habitat Evaluation Index (QHEI) was originally designed by the Ohio EPA to provide a quantitative evaluation of the physical characteristics and is used as a planning and design tool for stream assessment and restoration. This study evaluates the applicability of the QHEI to stream assessments in Southern Ontario. QHEI assessments were made at 67 sites in Ontario where benthic data were available. High QHEI scores indicate quality streams, whereas low QHEI scores are associated with degraded systems. This study shows that only 7 of the 21 QHEI sub-metrics correlate with %EPT, HBI and family richness. Therefore, predictive regression equations were developed and can be used to assist in the stream assessment and rehabilitation design processes by optimizing sub-index weights, thus giving a summation for Ontario streams that is better coupled to biological responses. The design ranges for the QHEI sub-metrics for the regression equations have been calculated. However, only about 50% of the variance in biologic indices was explained by geomorphic stressors within the stream and the other 50% might be related to upstream water quality or land-use. *Keywords: Streams, Assessments, Rural, Habitats, Remediation.*

<u>GEBBINK, W.A.</u>[1], HEBERT, C.E.[1], WESELOH, D.V.C.[2], and LETCHER, R.J.[1], [1]Wildlife and Landscape Science Directorate, Science and Technology Branch, Environment Canada, National Wildlife Research Centre, Carleton University, Ottawa, ON, K1A 0H3; [2]Canadian Wildlife Service, Environment Canada, Downsview, ON, M3H 5T4. **Spatial Trends of Perfluorinated Carboxylates and Sulfonates and Precursor Compounds in Eggs of Colonial Herring Gulls and the Influence of Dietary and Food Web Sources.**

Environmentally important perfluorinated carboxylates and sulfonates, as well as precursors were determined in herring gull (Larus argentatus) eggs collected (in 2007) from 15 colonies located across the Laurentian Great Lakes. The pattern of perfluorosulfonates (PFSAs;

C6, C8, C10) was dominated by PFOS (>90% of ΣPFSA) regardless of location. The ΣPFSA concentrations were significantly (p<0.03) higher in eggs from Middle Island, Toronto Harbour and Strachan Island compared to colonies on Lakes Superior, Michigan and Huron. C8 to C15 perfluorocarboxylic acids (PFCAs) were detected in the eggs with PFUnA and PFTrA being the dominant compounds. The highest concentrations of ΣPFCA were found in eggs collected from Double Island, followed by colonies on Lake Erie and Ontario. These results indicated that the spatial distribution of PFSAs and PFCAs in herring gull eggs from the Great Lakes was a function of colony location, e.g., egg levels increased from the northwest to the southeast and were greater in eggs from colonies in close proximity to highly urbanized and industrialized sites in Lakes Erie and Ontario. Stable isotope (δ15N and δ13C) analysis of individual eggs collected from 5 colonies indicated that the aquatic component in the gulls' diet is the primary source of PFCs for most of those colonies. *Keywords: Perfluorooctane sulfonate, Herring gull, Spatial distribution.*

GEE, J.H.[1], DEBARROS, C.A.[2], and KOK, S.E.[1], [1]Environment Canada, 4905 Dufferin Street, Toronto, ON, M3H 5T4; [2]Ministry of Environment, Box 22032, 1259 Gardiners Road, Kingston, ON, K7M 8S5. **Status of Canada's Great Lakes Areas of Concern.**

Collaboration among many stakeholders, including federal, provincial and municipal governments, First Nations, conservation authorities, non-governmental organizations, industry, academia and local citizens has been the key to the significant progress made in restoring Canada's seventeen Great Lakes Areas of Concern (AOCs). The Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem between the federal and provincial governments fosters such collaboration and capacity building, and contributes to addressing Canada's commitment under the Canada-United States Great Lakes Water Quality Agreement. By the end of 2010, three AOCs will have been delisted [Wheatley Harbour (2010), Severn Sound (2002) and Collingwood Harbour (1994)]. Remedial actions have been completed for Spanish Harbour which was designated an Area in Recovery in 1999. Implementation of remedial actions is nearing completion in several AOCs and by 2015, at least two more AOCs will be delisted. This paper will present the status of (i) beneficial use impairments in the remaining AOCs, (ii) Remedial Action Plan implementation actions and (iii) delisting criteria development and targets. The paper will also highlight challenges in addressing delisting of the AOCs. *Keywords: Great Lakes basin, Areas of Concern, Hydroacoustics.*

GEWURTZ, S.B.[1], BHAVSAR, S.P.[2], JACKSON, D.A.[1], FLETCHER, R.[2], MOODY, R.[2], and REINER, E.J.[2], [1]Department of Ecology and Evolutionary Biology, University of Toronto, Toronto, ON, M5S 3G5; [2]Ontario Ministry of the Environment, 125 Resources Road, Toronto, ON, M9P 3V6. **PCBs and mercury in Ontario fish: influence of size and gender and implications for fish consumption advisories.**

Occurrence of PCBs and mercury in the Great Lakes is evident from fish consumption advisories due to these chemicals. Advice is generally given on a length-specific basis and fish gender is usually not considered although the influence of these factors is not well known. Here, we use the large dataset generated by the Ontario Ministry of the Environment and collaborators

to evaluate the relationship between PCB/mercury and length and gender. We evaluated seven of the most commonly consumed fish in the Canadian Great Lakes and two inland lakes. A power function was used to evaluate the relationship between concentration and length for each collection year. For mercury, the relationship between concentration and length was significant ($p<0.05$) in most of the fish species and locations. For PCBs, this relationship was also generally significant in chinook salmon and lake trout, which are the species with the most advisories for this compound. In contrast, significant relationships were not typically found for whitefish, northern pike, smallmouth bass, walleye, and yellow perch, although these species are generally of less concern with regard to PCB contamination. Gender differences were common for walleye (males>females, $p<0.05$) but not other species. *Keywords: Mercury, PCBs, Fish.*

GILBERT, J.G. and OLDENBURG, K., Lake Erie Management Unit, MNR, 1 Passmore Ave, P.O. Box 429, Port Dover, ON, N0A 1N0. **Ecological Assessment of Inner Long Point Bay, Lake Erie.**

The ability to effectively manage, restore and protect coastal wetland and nearshore habitats requires information regarding system health, stressors, and threats to future system integrity. Building upon a successful assessment model designed for and undertaken in Rondeau Bay (2005/06) a multi-component ecological assessment of Long Point Bay was undertaken between 2007 and 2009. Supported through funding from the Canada/Ontario Agreement, the Lake Erie Management Unit (MNR) along with numerous partners collected information on key components within wetlands, nearshore, inner bay and tributary sites. These components included fish, birds, anurans, herpetofauna, mussels, zooplankton, vegetation, bathymetry, water and sediment physical and chemical conditions, invasive species, species at risk, human disturbance, system alterations and development. This information will be collated into a comprehensive report to be used as a baseline on the health of the system. It will also be used as a basis for developing a strategic 'best bets' document intended to guide future planning and management resource decisions which take the entire system into consideration. Some of the findings from this assessment work will be discussed. *Keywords: Ecosystem health, Coastal ecosystems, Assessments.*

GILBERT, J.M.[1], LETOURNEAU, F.[2], PEACH, G.[3], JACOBS, D.[4], LOCKE, B.[1], and DROUIN, R.[1], [1]Lake Erie Management Unit, MNR, 659 Exeter Rd., London, ON, N6E 1L3; [2]Dover Agri-serve, RR #8, Chatham, ON, N7M 5J8; [3]Lake Huron Centre for Coastal Conservation, P.O. Box 178, Blyth, ON, N0M 1H0; [4]Moravian Town, Delaware Nation, R.R. #3 , 14729 River Line, Thamesville, ON, N0P 2K0. **Insight Gained on Effective Control of the Invasive Alien Species *Phragmites australis subsp. australis* (common reed) in Sensitive Great Lakes Coastal Habitats.**

Recent invasions by the aggressively spreading invasive Phragmites, within critically important and sensitive coastal systems has provided the impetus to pursue control options. At issue is the ability to effectively and efficiently control the invasive plant, using current, legally available tools, without causing significant harm to the native flora and fauna. Control projects in dunes and wetlands conducted over the past few years have resulted in both successes and

failures. The knowledge gained from these projects has been invaluable and is highly relevant for increasing success in similar systems. Factors including chemical and mechanical control options, timing, site conditions, pre and post treatment requirements, stand density and height, community outreach, legal requirements, and proposed legislation changes will be discussed. *Keywords: Coastal ecosystems, Phragmites australis sunsp. australis, Invasive species, Management.*

GINN, B.K., DENNIS, M., and BALDWIN, R., Lake Simcoe Region Conservation Authority, 120 Bayview Parkway, Newmarket, ON, L3Y 4X1. **Sediment phosphorus and the potential for internal loading in Lake Simcoe and the Holland River (Ontario, Canada).**

Lake Simcoe has been the focus of many environmental studies due to concerns of increased nutrient loading and declines in coldwater fish habitat. One area which has not been studied in detail, and a component missing in current water quality models, is the amount of phosphorus (P) in sediments and their potential for release (i.e. internal loading). In this study we measured sediment P in Lake Simcoe and the Holland River both spatially (20 lake and 6 river stations) and temporally (from Feb. to Nov.) in order to assess (1) current P concentrations in the lake, as well as differences between areas; and (2) seasonal changes in these concentrations. Using a GIS-based kriging approach, we constructed a map of sediment P with statistically validated interpolations to identify areas for further study. Our results suggest that while seasonal changes in sediment P are relatively minor, there is a significant sediment reservoir and potential for release under low oxygen conditions – conditions known to occur in the lake on both a diurnal and seasonal basis. Nearshore sample stations consistently had higher P concentrations than offshore sites which may indicate the shunting of nutrients by invasive dreissenids. Also of interest were very low P concentrations recorded in upper Cook's Bay – an area of high aquatic P and plant biomass. *Keywords: Phosphorus, Lake Simcoe, Sediments.*

GINN, B.K. and YEREX, G., Lake Simcoe Region Conservation Authority, 120 Bayview Parkway, Newmarket, ON, L3Y 4X1. **Benthic invertebrates, environmental degradation, and the extent of Dreissenid colonization in Lake Simcoe (Ontario, Canada).**

Lake Simcoe is the largest inland lake in southern Ontario and one of the foremost recreational ice fishing destinations in Canada. While this lake has been the focus of much public and scientific attention due to increased nutrient loadings and declines in coldwater fish habitat of the offshore zone, the nearshore zone (0-20 m) has, until recently, been virtually ignored. In Lake Simcoe, this zone occupies 66% of the lake area, is an important terrestrial-aquatic linkage, and is the area of the lake which has likely undergone the most significant environmental degradation due to shoreline alteration, land-use changes, and invasive species. In this study, benthic invertebrate communites were used to assess the current state of three lake habitats: shoreline (0-1 m), littoral (~7 m) and profundal (20-40 m). By comparing with previous studies, we were able to track a degradation of nearshore environmental quality: shallow habitats are undergoing a loss of species diversity and starting to resemble deeper sites. In addition, littoral communities are dominated by two invasive dreissenid species. In order to more fully understand the impact these exotics are having on Lake Simcoe, we sampled over 800 sites in the lake and,

using a GIs-based kriging approach, investigated the distribution and density of zebra and quagga mussels. *Keywords: Invasive species, Benthos, Dreissena.*

GISLASON, D.[1], REID, K.[1], and OLDENBURG, K.[2], [1]Ontario Commercial Fisheries Association, 45 James St, Blenheim, ON, N0P1A0; [2]Ontario ministry of Natural Resources, Lake Erie Management Unit, Port Dover, ON. **Assessment and mitigation of the effects of commercial fishing activities on aquatic SARs in Long Point Bay.**

The objectives of this project were to assess, reduce or eliminate possible incidental harm to aquatic Species At Risk (SAR) that might be associated with commercial fisheries in Long Point Bay. Commercial fishing activities were monitored from early April until May 13 (when fishers are required to pull their gear), and resumed when commercial activity started again after August 31 until fishers pull out their gear for the winter. During the fishing season 368 hoop nets lifts were monitored for aquatic SARs, all SARs were documented and geo-referenced and photos for later accurate identification of species by specialists taken when conditions permitted. Of aquatic SAR's Warmouth (*L. gulosus*) was in most common in hoop nets, with 0.38 Warmouth/lift, other SAR fish species were less common with 2 observation of Grass Pickerel, (*Esox americanus vermiculatus*), and 1 observation of Spotted Gar (*L. oculatus*). Of SAR turtles only the Northern Map turtle (*Graptemys geographicawas*) was frequently caught in nets. A invasive species, Rudd, (*Scardinius erythrophthalmus*), that has not been reported in inner Long Point Bay, was observed 3 times and has thus higher frequency in fishing gear than some SARs species. All aquatic SAR's survived in the hoop nets for 24 hours and were released alive. *Keywords: Species at risk, Commercial fisheries, Impacts.*

GLASS, W.R.[1], CORKUM, L.D.[1], and MANDRAK, N.E.[2], [1]University of Windsor 401 Sunset Ave., Windsor, ON, N9B 3P4; [2]Department of Fisheries and Oceans 867 Lakeshore Rd., Burlington, ON, L7R 4A6. **Evaluating Habitat Utilization of the Threatened Spotted Gar (*Lepisosteus oculatus*) in Rondeau Bay with the Aid of Radiotelemtry.**

The Spotted Gar is a species designated as Threatened in Canada under the federal Species at Risk Act. Identification and protection of critical habitat is an important component of recovering species at risk. Identification of critical habitat requires an understanding of habitat utilization by life stage. To better understand the habitat utilization of the Spotted Gar in Rondeau Bay, a shallow coastal wetland of Lake Erie, external radio transmitters were surgically attached to 37 adult specimens in May of 2007. These individuals were tracked throughout the summer and fall of 2007. Habitat and water chemistry data were collected at all gar locations found by tracking. Tracking resulted in 212 discrete locations. Preliminary analyses indicated that aquatic macrophytes were present at 192 (91%) of these sites. Based on the tracking locations, home range was calculated. General movement patterns showed individuals utilized nearshore habitat in the spring, and moved offshore as the summer progressed, often taking up residence in offshore weedbeds. The results of this study are being used by the Spotted Gar Recovery Team to identify critical habitat in Rondeau Bay *Keywords: Habitats, Species at Risk, Fish.*

**53rd Annual Conference on Great Lakes Research
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AGLR 2010
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GLEASON, M., Great Lakes Naval Memorial and Museum, Muskegon, MI, USA.
The use of ROV Technology to survey, map and evaluate Great Lakes Shipwrecks while Providing Education.

Many of Great Lake's shipwrecks are rarely visited by the non-diving public or evaluated by agencies on a yearly basis. Often agencies visit only the wrecks that are used by the public and neither, rarely visit deep wrecks, ones that are in water over 200 feet. Improvements in underwater technology in the areas of Remotely Operated Vehicles and Side Scan Sonar result in a cheaper, more practical method to evaluate wrecks and the results can be incorporated into educational programming. This presentation will review an effort demonstrating the use of ROVs and Side Scan to undertake searches and evaluations of shipwrecks while involving the public in the efforts.The Great Lakes have thousands of shipwrecks but water borne exotics have started to have an effect. While the shipwrecks have survived for decades unchanged the impacts of exotics such as the zebra mussels have dramatically change the appearance of our wrecks by covering the surface areas. The impacts of exotics, scuba divers and in the case of shallow wrecks the weather should be evaluated by the agencies that are responsible for these important resources.Today, technology's allows results from ROVs to be shared with the public on the web or through live broadcasts. *Keywords: Education, Management.*

GOGINENI, P., JANUSKA, B., MINNIEFIELD, C., and SIMOLIUNAS, S., Detroit River Remedial Action Council, 665 W, Warren Avenue, Detroit, MI, 48201, USA.
High residual Chlorine from CSO Retention Basins.

Combined sewer overflows in some cases were corrected by building retention basins. The disinfection is accomplished usually by the use of chlorine or sodium hypochlorite. Since the disinfectant contact time is short, the residual chlorine is high. Thus, dechlorination facilities will have to be built. However, the organochlorines produced will have to be carbon treated. The states permitting such disinfection instead of ozonation have injured the Clean Water Act greatly. *Keywords: Combined Sewer Overflow, Chlorine, Retention Basins.*

GOODWIN, R.A.[1], NESTLER, J.M.[2], ANDERSON, J.J.[3], and SMITH, D.L.[2], [1]U.S. Army Engineer Research & Development Center, CENWP-EC-HD, 333 SW 1st Ave., PO Box 2946, Portland, OR, 97208; [2]U.S. Army Engineer Research & Development Center, CEERD-EP-W, 3909 Halls Ferry Rd., Vicksburg, MS, 39180-6199; [3]School of Aquatic & Fishery Sciences, University of Washington, Columbia Basin Research, 1325 4th Ave., Suite 1820, Seattle, WA, 98101.
ELAM Neurobiology Describing Animal Movement Decision-Making Behavior in Changing Environments.

Movement is a fundamental population process, but a relatively new topic in ecology and poorly understood. While studies recognize the importance of population density and social forces on movement within and between habitats, management of aquatic habitat is often limited to alternatives in geometry, flow, and water quality. Few tools directly relate these managed attributes to movement in a manner recognizing the importance of limited information at the

individual level due to varying sensory acuity and acclimatization based on past experience, changes in internal state, irregularity and partial preferences in decisions, interactions between physiological and stimulus-related factors affecting motivation, and continuous behavior adjustments in response to these factors. Fish are not primitive in these respects. Using field movement data we demonstrate the utility of a Eulerian-Lagrangian-agent Method (ELAM) for analysis of the process-based relationships between patterns in movement and managed environmental stimuli. Simply, an ELAM is a particle-tracking model (PTM) within an engineering model of the aquatic environment and algorithms describing how animals perceive and respond to multiple environmental stimuli through time developed from emerging theory in neurobiology, cognitive ecology, and decision-making research. *Keywords: Fish behavior, Hydrodynamics, Spatial analysis.*

GORMAN, O.T. and YULE, D.L., USGS-Lake Superior Biological Station, 2800 Lake Shore Drive East, Ashland, WI, 54806. **Habitat Coupling by Fishes of Lake Superior across Inshore, Nearshore, and Offshore Waters.**

We sampled fish with variety of gear types across inshore (0-15 m depth), nearshore (15-80 m) and offshore (>80 m) habitat zones of the Apostle Islands region of Lake Superior during day and night periods. Bottom trawls were used day and night across all habitat zones and midwater trawls and hydroacoustics were used at night in the near- and offshore habitat zones. Two common diel patterns of migration were observed, horizontal movement up banks and vertical movement up the water column at night and the reverse during daylight. Lake trout, lake whitefish, pygmy whitefish, trout-perch, and burbot migrated up the bank at night, while lake cisco, bloater, kiyi, and rainbow smelt showed upward vertical migration at night. Sculpins did not show migration from their benthic-demersal habitat. Ninespine stickleback showed upward vertical migration at night at depths > 60 m but not in shallower zones. Diel movement of the fish community serves to trophically link habitat zones and enhance energy transfer throughout the lake. *Keywords: Lake Superior, Habitat coupling, Habitats, Energy transfer, Fish, Trophic linkages.*

GORNEY, R.M. and WATZIN, M.C., Rubenstein Ecosystem Research Laboratory, 3 College Street, Burlington, VT, 5401, United States. **Diet analysis of invasive planktivorous fish species in Missisquoi Bay, Lake Champlain.**

Through stomach content analysis, we evaluated seasonal shifts in diet preferences of two species of invasive planktivorous fish in Lake Champlain. Missisquoi Bay is a shallow, eutrophic bay that has recently begun to experience toxic cyanobacteria blooms in summer months. Alewife (*Alosa psuedoharengus*) and white perch (*Morone americana*) have only recently entered this system and their respective impacts on the lake food web remain to be fully understood. Fish were sampled monthly using multi-mesh gillnets during the summer months of 2009. Our results indicate remarkable plasticity and high diet overlap between the two species. Prey item selection shifts over the growing season are characterized by diets almost completely consisting of zooplankton in early summer, followed by a shift to benthic invertebrates in later months. High nutrient levels and selective predation on large zooplankton by the fish may be

leading to a trophic cascade and algal blooms. Our study has implications for better understanding the mechanisms controlling bluegreen algal blooms and the impacts of invasive fish species. *Keywords: Trophic level, Lake Champlain, Invasive species.*

GRABUSKI, J.M., CAGAMPAN, S.J., and STRUGER, J., Environment Canada, 867 Lakeshore Rd, Burlington, ON, L7R4A6. **Automated Solid Phase Extraction and LC-ESI/MS/MS analysis of Carbamate Insecticides and Sulfonyl Urea Herbicides in Natural Water Samples.**

Identification and determination of certain polar pesticides has 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 have developed sensitive and robust analytical techniques with supporting method detection limits (MDLs) and stability data using fortified Type I water. Pesticide classes we have focused on are the sulfonyl & phenyl urea herbicides and carbamate insecticides. Current lists include twelve sulfonyl urea's and six related herbicides (henceforth referred to collectively as SUs), and seven carbamate insecticides. Each method involves the extraction of 500-800 mL of water using the automated Autotrace SPE Workstation at a flow rate of 5mL/min, elution as per each method followed by concentration to 1mL for analysis by LC/ESI-MS/MS. Recoveries of SUs from spiked Type I water were greater than 75% for all compounds except rimsulfuron (53%), nicosulfuron (63%), and tribenuron-methyl (28%). The corresponding MDL ranged from 0.7 – 22.0 ng/L. Recoveries for the carbamates in spiked Type I water samples were greater than 87% for all compounds and the MDL ranged from 0.16 – 0.70 ng/L. *Keywords: Environmental contaminants, Pesticides.*

GRANADOS, M., McGill University, 1205 Docteur Penfield, Montreal, QC, H3A 1B1. **Multivariate analysis of fish communities the Toronto Harbour.**

The inextricable relationship between fishes and their habitat permits the interpretation of site condition through fishes. Environmental conditions that exceed the thresholds for a given species preclude the presence of the species, while conditions within the bounds of the species' tolerance facilitate its persistence. Modification of abiotic conditions can induce changes in the fish assemblage, as the fish-habitat association effectively dissolves. Conversely, changes towards a reference assemblage can indicate a response to habitat rehabilitation. Multivariate analyses allow the visualization of species composition changes in reduced space. Principle Coordinates Analysis (PCoA), a multivariate method that permits the expression of site similarity as a function of species composition through distance, was applied to a 20-year data set from the Toronto Harbour to detect changes in the fish assemblage in response to habitat remediation. Reference assemblages were plotted simultaneously with test sites to determine whether test sites were approaching the reference assemblages in ordination space. Confidence ellipses drawn around the reference assemblages provided delineation of group membership. *Keywords: Multivariate, Assessments, Indicators.*

GRANADOS, M.[1], MANDRAK, N.E.[2], and JACKSON, D.A.[3], [1]McGill University, 1205 Docteur Penfield, Montreal, QC, H3A 1B1; [2]Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [3]University of Toronto, 25 Willcocks Street, Toronto, ON, M5S 3B2.
Detecting Changes in Fish Communities in Response to Habitat Rehabilitation: A Comparison of Multimetric and Multivariate Approaches.

Bioassessment can be performed through several methods and with different bioindicators. In Canadian Areas of Concern (AOC), fishes are used as a proxy for site condition. The Index of Biotic Integrity (IBI), a multimetric index for biological assessment, has been applied to fish data across Canadian AOCs to detect recovery. Some studies have indicated the IBI is not sensitive to assemblage changes characteristic of later stages of recovery. In this study, the IBI and multivariate methods were applied to data from two AOCs, the Detroit and St. Clair rivers to determine if the IBI is an appropriate assessment method for AOCs. The results revealed the IBI is susceptible to species substitutions within metric categories. The substitutions produced high variability within narrative ranks and rendered the IBI insensitive to species-specific changes in the fish assemblage. Multivariate methods detected changes in the fish assemblage over the course of sampling in the Detroit and St. Clair rivers. The direction of the change was determined through the development of a reference assemblage constructed from the results of a best professional judgment survey. The results of this study indicate multivariate methods may be more appropriate than the IBI to monitor responses to remediation over the entire course of recovery. *Keywords: Indicators, Detroit River, St. Clair River.*

GRANNEMANN, N.G., U.S. Geological Survey, 6520 Mercantile Way, Suite 5, Lansing, MI, 48911. **History of Estimated Rates of Groundwater Discharge to the Great Lakes.**

Although the total amount of direct groundwater discharge to the Great Lakes is not known, many local and a few regional estimates of rates have been made and are available in published sources. This paper reviews the rates of groundwater discharge estimated from the 1970s until present. Rates are best known in the Lake Michigan basin. Groundwater is a major natural resource in the Great Lakes basin and it is important to have a better understanding of the roles that groundwater plays in the over all hydrologic system of the Lakes. *Keywords: Great Lakes basin, Hydrologic budget, Watersheds.*

GRONEWOLD, A.D.[1], HUNTER, T.S.[2], and STOW, C.A.[2], [1]United States Environmental Protection Agency, Research Triangle Park, NC, 27711; [2]National Oceanic and Atmospheric Administration, Ann Arbor, MI, 48108. **Novel Modeling Tools for Propagating Climate Change Variability and Uncertainty into Hydrodynamic Forecasts.**

Understanding impacts of climate change on hydrodynamics and ecosystem response within the Great Lakes is an important and challenging task. Variability and uncertainty in environmental conditions and model forecasts, coupled with the broad range of spatial and temporal scales at which processes can be represented, contributes to significant gaps in this understanding. We attempt to close these gaps by first employing an exponential-dispersion (ED)

model to reconstruct long-term precipitation dynamics throughout the Great Lakes region. The parameters of the ED model can be interpreted as linear functions of common precipitation metrics (including event intensity, event duration, and duration between individual events) allowing us to apply a calibrated ED model under regional scale climate change scenarios to simulate future precipitation dynamics. We apply these findings to competing rainfall-runoff models across watersheds throughout the Great Lakes region. Our results highlight relative magnitudes of intra- and inter-model variability, and how variability propagates into different management decisions under future climate change scenarios. *Although this work was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy. Keywords: Climate change, Hydrodynamics, Model studies.*

GRONEWOLD, A.D.[1], NEVERS, M.B.[2], and WHITMAN, R.L.[2], [1]United States Environmental Protection Agency, Research Triangle Park, NC, 27711; [2]U.S. Geological Survey, Ann Arbor, MI, 48105.
Improving Recreational Water Quality Assessments through Novel Approaches to Quantifying Measurement Uncertainty.

Bacteriological water quality in the Great Lakes is typically measured by the concentration of fecal indicator bacteria (FIB), and is reported via most probable number (MPN) or colony forming unit (CFU) values derived from algorithms relating "raw data" in a FIB analysis procedure (e.g. number and volume of sample aliquots) to the FIB concentration. Although this raw data contains all of the information necessary to quantify variability in the FIB concentration, it is rarely reported (and commonly discarded) after calculating an MPN or CFU value. Here, we introduce a set of novel probabilistic and Bayesian modeling tools for propagating FIB concentration uncertainty from this raw data into model-based water quality forecasts. Potential benefits of our approach include a more defensible representation of model forecast uncertainty, the ability to combine bacteriological water quality data derived from different testing procedures (while incorporating their unique intrinsic sources of uncertainty and bias), and a potential foundation for establishing new water quality standards based not on method-specific MPN or CFU values, but on a probabilistic representation of the FIB concentration itself. *Although this work was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy. Keywords: Assessments, Water quality, Monitoring.*

GROOTENDORST, K., DHANJAL, H., and BRUNTON, A., W.F. Baird & Associates, Oakville, ON.
Use of GIS Tools to Determine a Spatially-Distributed IPZ-3 Area Vulnerability Factor in Source Water Studies.

The area vulnerability factor (AVF) for IPZ-3 source water zones vary spatially with watershed hydrologic characteristics and with the distance from the intake. However, many studies rely on a 'lumped' approach and determination of scores on a subwatershed basis. In this study, the AVF was calculated in accordance with MOE rules within a GIS using raster-based datasets and a decision making model. This accounts for within-subwatershed variations in controlling factors, and delivers a parcel-based vulnerability raster dataset to support future watershed planning decisions. The results are consistent with other IPZ-3 scores, yet deliver a

much greater resolution. The methodology and rationale for this GIS-supported approach are presented, along with results for the Ottawa River Source Protection Region. *Keywords: Watersheds, Source Water Protection, Water quality.*

GRUSH, J., <u>VERHAMME, E.M.</u>, DEPINTO, J.V., and REDDER, T.R., LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108. **Application of a Fine-Scale 3-D Water Quality Model to Maumee Bay and the Western Basin of Lake Erie.**

Through its participation in the Western Lake Erie Basin Partnership and its responsibilities for the WRDA 516(e) and 204 programs, the USACE has been planning and working within the Maumee watershed to reduce the loading of solids and nutrients to the Maumee River and the western basin of Lake Erie. There is a need, however, to quantitatively connect watershed management efforts to ecosystem endpoints in Toledo Harbor, Maumee Bay and the western basin of Lake Erie. The ecosystem goals for this project include: reduction of sediment deposition in the navigation channel, reduction of hazardous algal blooms of *Microcystis* in the lower Maumee River and its plume, and reduction of nearshore nuisance algal growth and its fouling of shorelines. In order to make the quantitative connection between watershed activities and ecosystem improvement goals, we have applied a linked hydrodynamic – sediment transport – water quality model from the lower dredged portions of the Maumee River out into the entire western basin of Lake Erie. This presentation will focus on the development of the water quality model and show some preliminary results from model calibration and application. *Keywords: Water quality, Maumee Bay, Model studies, Lake Erie.*

<u>GUDIMOV, A.</u>[1], RAMIN, M.[1], STREMILOV, S.[1], LABENCKI, T.[2], BOYD, D.[2], and ARHONDITSIS, G.B.[1], [1]University of Toronto, Toronto, ON; [2]Ontario Ministry of the Environment, Toronto, ON. **Eutrophication Risk Assessment in Hamilton Harbour: System Analysis and Evaluation of Nutrient Loading Scenarios.**

Our objective is to develop a biogeochemical model that can effectively describe the interplay among the different ecological mechanisms modulating the eutrophication problems in Hamilton Harbour, Ontario, Canada. The model is used to address the following questions: What is the current status of meeting the objective of delisting the study system as an Area of Concern? What is the likelihood of meeting the water quality targets? How fast are we getting there? In this regard, the present modeling study undertakes an estimation of the critical nutrient loads in the Harbour based on acceptable probabilities of compliance with different water quality criteria (e.g., chlorophyll a, total phosphorus). Our model suggests that the water quality goals for TP (17 µg L-1) and chlorophyll a concentrations (5-10 µg L-1) will likely be met, if the Hamilton Harbour RAP phosphorus loading target at the level of 142 kg day-1 is achieved. We provide evidence that the anticipated structural shifts of the zooplankton community will determine the restoration rate as well as the stability of the new trophic state in the Harbour. Finally, we discuss the next enhancements of the Hamilton Harbour model and conclude by emphasizing the importance of rigorously assessing the uncertainty associated with model structure and parameters. *Keywords: Water quality, Phosphorus, Mathematical models, Phytoplankton, Eutrophication, Risk assessment.*

GUTIERREZ, L.[1], LIAO, Q.[1], and BOOTSMA, H.A.[2], [1]Department of Civil Engineering and Mechanics, University of Wisconsin-Milwaukee, Milwaukee, WI, 53211; [2]Great Lakes WATER Institute, University of Wisconsin-Milwaukee, Milwaukee, WI, 53204.
Hydrodynamic study of mass exchange between nearshore and offshore waters in Lake Michigan.

Configuration and validation of a 3D model which simulates the nearshore hydrodynamics in Lake Michigan near Milwaukee, Wisconsin (USA) is presented using the unstructured grid Finite Volume Coastal Ocean Model (FVCOM). This model is set in order to study the coastal hydrodynamic circulation and exchange of mass between the nearshore and offshore waters, as well as the transport and fate of both dissolved and particulate phosphorous in the nearshore waters of Lake Michigan. Driven by meteorological forcing observed around Lake Michigan and measured from several buoy based sensor network near Milwaukee, the whole lake circulation over 2008 is simulated and validated by comparing model simulations of current speed /direction and thermal structure with measured values in the lake. The result from the whole lake simulation is then used to supply open-lake boundary conditions for the high-resolution coastal model near Milwaukee. This detailed nearshore model is applied to examine the relative importance of different processes that determine the relation between nearshore phosphorus concentration and phosphorus loading from the Milwaukee River. These processes include: nearshore hydrodynamics, settling and resuspension of sediment, filtration and excretion by invasive zebra and quagga mussels, and the nearshore-offshore exchange. *Keywords: Lake Michigan, Mass exchange, Hydrodynamic model, Phosphorus.*

GUTOWSKY, L.F.G.[1], FOX, M.G.[2], and RABY, G.D.[1], [1]Department of Biology, Carleton University, Ottawa, ON, K1S 5B6; [2]Environmental & Resource Studies Program and Department of Biology, Trent University, Peterborough, ON, K9J 7B8.
Spatio-temporal variation in life history traits in an invasive species during its range expansion phase: round goby (*Neogobius melanostomus*) in the Trent River.

We assessed changes in the life history traits of an expanding population of invasive round goby (*Neogobius melanostomus*) in early and newly established sites in the Trent River (Ontario), over a two year period. The round goby was introduced in the middle portion of the river (CORE area) in 2003. In 2007, round gobies sampled at the upstream edge of their expanded range had higher reproductive energy allocation, lower age at maturity, smaller size at maturity and faster growth than those resident in the CORE area. In 2008, round gobies sampled from the upstream area established in the previous year showed decreased growth from the year before, and gobies in both this area and the CORE showed a shift in life history strategy toward increased reproductive allocation. Round gobies in the newly established downstream edge had the highest reproductive effort, earliest age at maturity and the smallest length at maturity of the three area. The dynamic life history changes were generally consistent with shifts in density and prey abundance observed during the study period. The decline in goby density and shift in life history traits observed in the CORE between 2007 and 2008 may reflect the 'boom and bust' population phenomenon observed in other species invasions, where abundance of the invader declines to an equilibrium level. *Keywords: Round goby, Invasive species, Life history studies.*

GUTREUTER, S., BARTSCH, M.R., BARTSCH, L.A., VALLAZZA, J.M., RICHARDSON, W.B., and KNIGHTS, B.C., U.S. Geological Survey, 2630 Fanta Reed Road, La Crosse, WI, 54603.
Preliminary Observations on Fish Tissue Lipid Quantity and Quality Associated with Spatial Patterns in the Distribution of Asian Carp.

The planktivorous Asian carps have the potential to sequester large amounts of energy, carbon and essential biochemicals from the foodwebs of North American waters because large-bodied adults have no natural predators. Relatively few biochemicals are essential to vertebrates, and among them the essential omega-3 fatty acids EPA and DHA are produced, de novo, only by certain algae. Therefore the Asian carp, and especially the silver carp, have the potential not only to divert energy, but also induce deficiencies in the fatty acids necessary to maintain cell-membrane fluidity, neural function, and reproduction. Dorsal muscle tissue of native planktivorous bigmouth buffalo, gizzard shad and paddlefish collected from Pool 26 of the Mississippi River, where Asian carp were abundant, averaged less than 5% lipid whereas those collected from Pool 8, where Asian carp were rare, averaged 7 to 15% lipid. Muscle tissue of the Asian carp from Pool 26 had similarly low lipid content suggesting that they may not be more efficient than native species in sequestering structural lipids. The essential omega-3 fatty acids were also reduced in muscle tissue from the native planktivores in Pool 26. The whole-body total lipid content of age-0 bluegill averaged approximately 15% from both Pool 8 and Pool 26.
Keywords: Invasive species, Lipids, Food chains, Fatty acids, Ecosystems.

GUZZO, T.M., HAFFNER, G.D., SORGE, S., and FISK, A.T., 401 Sunset Ave., Windsor, ON, n9b 3p4.
Linking Sources of Primary Production to Fish Production in the Western Basin of Lake Erie.

The Western Basin of Lake Erie is the most productive of the Laurentian Great Lakes and supports one of the world most robust freshwater fisheries. The basin is fed by two major rivers, the Detroit and Maumee, which create nutrient rich plumes at their effluent. Questions exist on the how these two rivers contribute to productivity in the basin and the effect that these river plumes have on larval fish survival and recruitment. Spatial and temporal variability of stable isotopes of carbon and nitrogen and polychlorinated biphenyls (PCBs) were used to delineate the relative importance of two major nutrient sources (Detroit and Maumee Rivers) to fish production in the Western Basin of Lake Erie. The Maumee River is a major source of allochthonous carbon to the system and is predicted to be the primary driver of the basins food web. Zooplankton, zebra mussels and young of year (YOY) white and yellow perch were collected from June through September 2009. Using isotope and PCB signatures from each river plume as references, we will determine the relative contribution of each river to zooplankton and zebra mussel biomass and trace YOY fish back to their respective brooding grounds.
Keywords: Stable isotopes, Lake Erie, PCBs.

GWYN, E.M.[1], FERGUSON, G.[1], SCHAEFER, K.[2], and KRANTZBERG, G.[3], [1]1 Stone Rd,, W., 2nd floor, Guelph, ON, N1G 4Y2; [2]867 Lakeshore Rd, Burlington, ON; [3]1280 Main St. W,

Hamilton, ON. **Knowledge Translation and Transfer – From Research Topics to Policy and Program Development – Examples from Ontario.**

Creating and sharing scientific knowledge is a proactive process. It starts with great research. Great research starts with great ideas. Where do these ideas come from? If the research project is complete and ends with a scientific publication is that knowledge shared? What needs to be done to help research results guide policy development? The arena of knowledge translation and transfer (KTT) focuses on enhancing wide input to the process of priority setting, of sharing knowledge and on accelerating the uptake by end-users. Ontario Ministry of Agriculture, Food and Rural Affair's (OMAFRA's) renewed focus on KTT within research programs is helping to address these questions and others to enhance the linkages between research and policy. We will provide examples using OMAFRA's environmental sustainability research program. This program involves 3 types of research projects: internally and externally competitive research, and an OMAFRA-University of Guelph research partnership. Also, to optimize end-user receptivity and uptake, more insight is required into their knowledge seeking behaviour. Information can then be better packaged to their preferences. We review a recent Environment Canada and McMaster University-led study that explores the science-seeking behaviour of Conservation Authorities in Ontario. *Keywords: Ontario Ministry of Agriculture, Food and Rural Affairs, Policy making, Knowledge translation.*

HAGLEY, C.A.[1] and SASS, D.J.[2], [1]144 Chester Park, 31 W. College St., Duluth, MN, 55812, UNITED STATES; [2]U.S. Environmental Protection Agency Great Lakes National PRogram Office, 77 West Jackson Boulevard (G-17 J), Chicago, IL, 60604. **Shipboard and Shoreline Science on the R/V Lake Guardian.**

The Center for Ocean Science Education Excellence Great Lakes (COSEE GL) sponsored two Shipboard and Shoreline Science Workshops in the summer of 2009. The workshops provided unique opportunities for educators in grades 4-10 and scientists to spend a week at sea together, conducting research and learning side-by-side as the US EPA R/V Lake Guardian traversed the Great Lakes. Intensive interactions between scientists and educators fostered by these workshops improved educators' abilities to use real-world science in the classroom and scientists' abilities to address broader impacts of their work. Highlights of these cruises will be presented, and will include: teacher investigations of the lower food web of Lake Superior and impacts of quagga mussels on the ecology of Lake Huron; Great Lakes curriculum development; and fostering teacher-scientist interactions. *Keywords: Education, Monitoring, Environmental education.*

HAJDUK, M.M.[1], BURLAKOVA, L.E.[2], MASTITSKY, S.E.[1], and KARATAYEV, A.Y.[2], [1]SUNY Buffalo State College, 1300 Elmwood Avenue, Buffalo, NY, 14222; [2]The Great Lakes Center, 1300 Elmwood Avenue, Buffalo, NY, 14222. **Hidden Invaders in the Great Lakes: Endosymbionts of Non-Native Species.**

Parasites introduced with non-native species may pose serious threat of epizootics to wildlife and human population. Surveys of Lake Erie and Lake Ontario, completed summer

2009, indicated the presence of ciliates, trematodes, nematodes, and oligochaetes associated with zebra mussels (*Dreissena polymorpha*) and quagga mussels (*Dreissena rostriformis bugensis*). *Chaetogaster limnaei* (oligochaete) was found in approximately 4% (n = 25) of zebra mussels sampled in Lake Erie's Eastern Basin, but was not present in quagga mussels. Unidentified trematodes were present in the Eastern and Western Basins in both zebra and quagga mussels, infecting nearly 40% of mussels sampled in the lake. Free-living nematodes were found in the mantle cavity of approximately 8% of zebra mussels (n = 25) and 5% of quagga mussels (n = 60). Additionally, 1.7% of quagga mussels had unidentified free-living oligochaetes. Gastropods *Bithynia tentaculata* and *Potamopyrgus antipodarum* were also examined. No endosymbionts were detected in *P. antipodarum*. However, a host-specific pathogenic trematode was found in *B. tentaculata*. Additional research and identification of the endosymbions of exotic species is needed to shed light on species composition, distribution, abundance and their possible ecological impacts. *Keywords: Invasive species, Endosymbionts, Lake Erie, Lake Ontario.*

HALL, J.D., Canada Centre for Inland Waters, 867 Lakeshore Rd, P.O.Box 5050, Burlington, ON, L7R4A6. **Leading with Science: The Hamilton Harbour Remedial Action Plan Experience in Integrating Research and Monitoring into Environmental Management Actions.**

Hamilton Harbour is the busiest Canadian harbour on the Great Lakes and for many years was the centre of heavy industry in Canada. Due to its significantly degraded environment, the Hamilton Harbour Remedial Action Plan was initiated in 1985 with its roots in scientific evaluation of various environmental conditions. Water quality, sediment toxicity, plant and animal communities, and habitat have been studied individually and concurrently over the years. Historical records date back to the 19th century with systematic investigations carried out from the 1960/70s onward. Hamilton Harbour has been in a unique position to benefit from science carried out at the federal Canada Centre for Inland Waters, and by provincial and local government agencies and universities. Science has been integrated and applied through technical teams, often brought together with members of the public and agency representatives responsible for undertaking environmental actions. This presentation will trace the history of Hamilton Harbour science and monitoring and describe a system put in place and refined to direct remedial actions; an ongoing practice of adaptive management. *Keywords: Ecosystem health, Research and monitoring, Remediation, Hamilton Harbour, Decision making, Adaptive management.*

HALPIN, K.[1], BOSCARINO, B.T.[1], RUDSTAM, L.G.[1], WALSH, M.G.[2], and LANTRY, B.F.[2], [1]900 Shackelton Point Road, Cornell Biological Field Station, Bridgeport, NY, 13030; [2]USGS Lake Ontario Biological Station, 17 Lake Street, Oswego, NY, 13126. **Age-specific responses to light by Great Lakes mysids.**

Light plays an important role in governing the vertical migration behavior and distribution of both the native Great Lakes mysid, *Mysis diluviana*, and the invasive mysid, *Hemimysis anomala*. In this study, we compare and contrast the light preferences and avoidance behaviors of adult and juvenile mysids of both species through laboratory observation analyses. Juvenile mysids of both species consistently preferred higher light levels than adults. Both age

classes of *H. anomala* preferred and were less sensitive to brighter light conditions than their *M. diluviana* counterparts. Vertical plankton tows and benthic sled samples taken in Lake Ontario from 2004-2009 at both nearshore and offshore sites suggest that juveniles emerge from the lake bottom earlier in the day and inhabit higher light habitats within water column than adults of both species. Our laboratory results corroborate the timing of emergence and migratory descent observed in the field for both age classes of *H. anomala* and can predict the nighttime vertical distribution of the different age classes of *M. diluviana* in Lake Ontario. These results have important implications for the role and physical presence of both species in benthic and pelagic Great Lakes food webs. *Keywords: Exotic species, Light, Experimental design, Migrations.*

HANN, B.J., Department of Biological Sciences,, University of Manitoba, Winnipeg, MB, R3T 2N2.
Compound Effects of Eutrophication, Stratification and Hypolimnetic Hypoxia on Zoobenthos in Lake Winnipeg.

Lake Winnipeg has experienced accelerated nutrient loading over the last 30 years resulting in significant changes in the zoobenthic community (e,g, increased abundance of oligochaetes and chironomids, decline in molluscs) at all depths in the lake. Typically considered a cold monomictic lake, well-mixed throughout its entire volume during the open water season, during midsummer of 2003, a deep thermocline at 13 -15 m was observed, separating a well-mixed oxygenated epilimnion from a cooler, hypoxic hypolimnion. Composition and abundance of major zoobenthic taxa at sampling stations within the 15 m isobath in August 2003 were compared with August 2002 and 2004 when there was no evidence of stratification of the lake.The observed depletion of zoobenthos may have long-term detrimental effects on components of the food web, especially lake whitefish. Depending on frequency of occurrence and duration of stratification in the north basin, ecosystem processes such as bioturbation of sediments, sedimentation of organic matter, and nutrient fluxes from sediments will also be negatively affected, with substantial impacts on the overall health of Lake Winnipeg. *Keywords: Benthos, Eutrophication, Lake Winnipeg.*

HANNA, E.A., REDISKE, R., and O'KEEFE, J., 2753 Woodlake rd SW, Apt 2, Wyoming, MI, 49519.
PBDEs in the Fish of Lake Huron.

Polybrominated diphenyl ethers (PBDEs) are used as flame retardants on a variety of products such as textiles, building materials, electronics, furnishings and plastics. Because of their endocrine disrupting abilities PBDEs are a concern for human health. Lake Huron and the other Great Lakes fish have been shown to accumulate elevated levels of PBDEs which causes concern for people who eat fish from this area. Fish were collected from Saginaw Bay and the Les Cheneaux islands in Lake Huron during the summer months of 2006. They were analyzed for 9 common congeners using GC-MS. Lipid content of the fish were determined to show lipid normalized congener concentrations. BDE-47 was the most abundant congener for all species and both sites. The fish from Saginaw Bay had a higher total concentration of PBDEs than the fish from the Les Cheneaux islands. Large Common Carp were the only fish that contained a significant amount of BDE-28. Large Largemouth bass contained a larger amount of BDE-99 than any of the other fish. This data is important to studying the effects of location, sex, and diet

on the total PBDE concentration and the congener patterns of different fish. *Keywords: Fish, PBDEs, Great Lakes basin.*

HANNA, E.E.[1], PETRIE, S.A.[2], and BADZINSKI, S.S.[2], [1]The University of Western Ontario, 1151 Richmond Street, London, ON, N6A 3K7; [2]Long Point Waterfowl, Box 160, 115 Front Street, Port Rowan, ON, N0E 1M0. **Population size, fall recruitment, and migratory habits of Eastern Population Sandhill Cranes (*Grus canadensis*) staging and breeding along the North Shore of Lake Huron, Ontario.**

Eastern Population (EP) Sandhill Cranes (*Grus canadensis*) have been increasing rapidly in the last 30 years, particularly within the last decade. In Ontario, the population staging and migrating along the North Shore of Lake Huron has increased from an estimated 40 breeding pairs in the late 1970s to a minimum of 6,200 birds counted in mid-October 2008 on Manitoulin Island alone. Increased crane numbers have resulted in a marked increase in crop depredation in the surrounding regions, creating distress amongst local agricultural producers. In fall 2009, population surveys were conducted over two months to capture the peak migratory period. The peak number was recorded October 7-8 ($n = 8,895$), representing approximately 25% of the EP and the highest count ever in Ontario. Fall recruitment was also assessed in 2009 by comparing numbers of after-hatch-year (AHY) to hatch-year (HY) birds in the population. Fall recruitment was estimated at 10.7%, (AHY: $n = 3,594$; HY: $n = 431$) suggesting continued population growth. In summer/fall 2010, AHY cranes ($n = 10$) will be captured and marked with GPS PTT satellite transmitters to study migration chronology, habitat use, and philopatry. This research will provide information that will assist in the management and conservation of cranes in Ontario. *Keywords: Satellite technology, Migrations, Avian ecology.*

HANSEN, T.H. and JANSSEN, J., UWM Great Lakes WATER Institute, 600 E. Greenfield Ave., Milwaukee, WI, 53204. **Creation, Implementation, and Practical Field Use of a Real-Time Bathymetry Mapping System Created with Open-Source Tools as an Adjunct to Multibeam Surveys.**

Detailed bathymetry is vital to studies of Great Lakes systems. However, the commonly available NOAA bathymetry charts are based on data which is typically at least 50 years old. In an effort to supplement the NOAA bathymetry, author Hansen, in 2006, installed an open-source database on a server computer aboard the R/V Neeskay, and set it to record the GPS and echosounder depth data produced by the ship's navigational equipment. In 2009, with nearly three years of soundings collected, Hansen created a system using all open-source tools, to produce bathymetry charts from the data. The system runs on the ship's computer, and is capable of continuously updating the chart display as the vessel is underway, incorporating the latest sounding data. The system proved itself during a recent bathymetric study of Lake Michigan's Northeast Reef. Co-author Janssen used the real-time bathymetry display to direct the ship's path to map the sections of highest interest. As a result, Janssen estimated that the cruise took half as long as originally planned. The resulting charts also allowed the follow-up multibeam study to pinpoint the most important spots, allowing co-authors Janssen and Wattrus to map the reef in

about one-fourth the time originally estimated. Complete system and platform details will be presented. *Keywords: Remote sensing, GIS, Spatial analysis.*

HANSON, A.M., YOUNG, E.B., and BERGES, J.A., University of Wisconsin - Milwaukee, 2200 E. Kenwood Blvd., Milwaukee, WI, 53211. **Viral lysis of freshwater bacteria provides phosphorus for P-starved eukaryotic algae.**

The ecological relevance of viruses in aquatic ecosystems is well established but not fully understood. Viruses in aquatic systems cause mortality and cell lysis of bacteria and phytoplankton. Cell lysis can release nutrients, which may be especially important in oligotrophic lakes, such as Lake Michigan, where phosphorus (P) availability is often limiting. This study examined the bioavailabilty of P released by viral lysis of bacteria, for P-starved eukaryotic algae. The heterotrophic bacterium *Pseudomonas reactans* and its virus PRV1 were isolated from Lake Michigan. Infection of *P. reactans* with PRV1 resulted in cell lysis. The lysate was supplied to axenic cultures of *Pseudokirchneriella subcapitata* and *Chlamydomonas reinhardtii*, which had previously been starved of P. Cell growth and Fv/Fm were monitored using chl *a* fluorescence. Dissolved and particulate P pools and alkaline phosphatase activity (APA) were measured. Addition of lysate to cultures stimulated growth of P-starved cells, but not nutrient replete controls. Response of APA varied between species, but general declines indicated alleviation of P stress. These results suggest that viral lysis of bacteria can release bioavailable P to freshwater algae. *Keywords: Microbiological studies, Viruses, Phosphorus.*

HARTIG, J.H.[1], ZARULL, M.A.[2], COOK, A.[1], and BOHLING, M.[3], [1]U.S. Fish and Wildlife Service, 9311 Groh Road, Grosse Ile, MI, 48138; [2]Environment Canada, National Water Research Institute, 867 Lakeshore Road, P.O. Box 5050, Burlington, ON, L7R 4A6; [3]Michigan Sea Grant, 640 Temple, 6th Floor, Detroit, MI, 48201. **Soft Shoreline Engineering: We Built It, Have They Come?**

Historically, many urban shorelines were stabilized and hardened to protect developments from flooding and erosion, or to accommodate industry (i.e., hard shoreline engineering). Today, there is growing interest in developing shorelines using ecological principles to reduce erosion and achieve stabilization/safety, while enhancing habitat, improving aesthetics, and even saving money (soft shoreline engineering). In 2008–2009, a survey of 36 soft shoreline engineering projects in the Detroit River-western Lake Erie watershed was conducted. In total, $16.5 million was spent on these projects. Of the 36 projects implemented, only six (17%) had any quantitative assessment of ecological effectiveness. The remaining 30 had no post-project monitoring or only a qualitative assessment. Key lessons include: involve habitat experts up front in waterfront planning; establish multiple objectives; ensure multidisciplinary project support; start with demonstration projects and attract partners; involve citizen scientists, volunteers, university students, and/or researchers in monitoring, and obtain commitments for post-project monitoring of effectiveness up front in project planning; measure benefits and communicate successes; and promote education and outreach, including public events that showcase results and communicate benefits. *Keywords: Shore protection, Rehabilitation, Habitats, Planning.*

HASNAIN, S.S.[1], MINNS, C.K.[2], and DOKA, S.E.[1], [1]Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [2]University of Toronto, 25 Wilcocks Street, Toronto, ON, M5S 3B2.
Cumulative Impact Assessment of Fish Habitat Changes along the Toronto Waterfront: Opportunities and Approaches.

In Canada, fish habitat changes are assessed under the Fisheries Act and the Canadian Environmental Assessment Act. Individual habitat alterations are usually small in area and below the scale needed to sustain populations and communities, especially top predators. Such improvements are usually assessed only against local conditions in the near-term. Human development in the Toronto Region has cumulatively impacted both adjacent watersheds and waterfront ecosystems of Lake Ontario. Aquatic Habitat Toronto is mandated to improve, restore and help create aquatic habitats along the waterfront. This provides opportunities to develop cumulative assessments over broader spatial and temporal scales as long-term action plans are developed, implemented and evaluated. Many examples of fish habitat creation along the Toronto waterfront provide a basis for developing alternative frameworks of cumulative impacts assessment. Initial static assessments of gains and losses were assessed at different scales including time lags in habitat creation. As the spatial and temporal scales for assessment increase: 1) explicit regional scenarios of development, resource use, and climate are needed; 2) static assessment tools must be replaced with dynamic ones; and 3) biotic factors such as movement patterns and genetic isolation need to be incorporated. *Keywords: Habitats, Remediation, Urban areas, Toronto & Region.*

HAWRYSHYN, J., RU¨HLAND, K., and SMOL, J.P., Paleoecological Environmental Assessment and Research Laboratory, Department of Biology, Queen's University, Kingston, ON, K7L 3N6.
Diving into Lake Simcoe's Past: A Paleolimnological Study of Lake Water Quality.

The multiple stressors impacting Lake Simcoe create challenges for lake and watershed management. Long-term perspectives are necessary to place lake water quality and the relative influence of different stressors into a historical perspective. Paleoecological data can extend the historical record of Lake Simcoe beyond the 30 years of valuable monitoring data to pre-disturbance conditions thereby providing insights into how conditions have changed over time. This paleolimnological study examines changes in sedimentary diatom assemblage composition over the last circa 150 years from a suite of radioisotope-dated cores retrieved from key locations in this large lake. Chl-a analysis of the sediment cores is used to track trends in primary production and will be presented alongside the diatom data. These high-resolution data provide evidence for changes in lake water quality consistent with recorded changes in land-use practices in the watershed, phosphorus remediation efforts, and species invasions. A diatom-based total phosphorus inference model is applied to all sedimentary sequences to assess changes in the lake's trophic history. Paleoecological data will be compared to historical and instrumental records. The combination of stressors has had cumulative effects on Lake Simcoe, making interpretation of results challenging. *Keywords: Paleolimnology, Diatoms, Lake Simcoe.*

HAXTON, T.[1], BRUCH, R.[2], and WHELAN, G.[3], [1]300 Water St., 4th Floor, S., Peterborough, ON, K9J 8M5; [2]625 E County Rd Y, Suite 700, Oshkosh, WI, 54901; [3]P.O. Box 30446, Lansing, MI, 48909.
Predicted Sustainable Harvest of Great Lakes Lake Sturgeon as Estimated by Markov-Chain Monte Carlos.

Lake sturgeon were historically overexploited in the Great Lakes and throughout their North American range. Current populations in the Great Lakes have been estimated to be less than 1% of historical values however, true historically population levels are unknown and difficult to ascertain. These levels are of interest and importance when discussing recovery strategies. Annual harvest (kgs) has been documented on all Great Lakes and inland waterbodies and provides what little information there is available to estimate historical abundance. To estimate historical abundance ($\beta0$) with associated levels of uncertainty, we used a Markov-chain Monte Chain approach using the Surplus-Production model. Effort, harvest and population estimates from the Lake Winnebago (WI) system from 1955 through 2008 were used to estimate (i.e., determine posteriors) of surplus-production parameters (r, K, $\beta0$). In turn, these were used as priors when running the Surplus-Production model for the Great Lakes to estimate historical biomass. The estimated carrying capacity (assumed also to be $\beta0$) of the Great Lakes ranged from 313 900 to 6 473 000 kgs, the intrinsic population growth rate ranged from 0.079 – 0.123 and theoretical sustainable exploitation rate ranged from 2 – 3.1% whereas it was estimated to be 4% on Lake Winnebago. *Keywords: Fish management, Fish populations, Productivity.*

HAYWARD, S.J.[1], GOUIN, T.[2], and WANIA, F.[1], [1]Department of Physical and Environmental Sciences, University of Toronto Scarborough, 1265 Military Trail, Scarborough, ON, M1C1A4; [2]Safety and Environmental Assurance Centre, Unilever, Colworth Science Park, Sharnbrook, MK441LQ, U.K..
Atmospheric Concentrations, Transport, and Temporal Trends of Pesticides in the Great Lakes Region.

There is intense agricultural activity in the Great Lakes region, with significant amounts of pesticides used each year. From 2006-2007 both active and passive air samplers were deployed in Egbert, an agricultural area north of Toronto, while from 2007-2008 a set of passive samplers were deployed for one year at several sites throughout Ontario. The latter transect showed high atmospheric concentrations of current-use pesticides (CUPs) in agricultural regions of southern Ontario, with much lower levels in the atmosphere at more remote locations. Only CUPs with significant atmospheric lifetimes, such as endosulfan and chlorothalonil are able to transport to regions remote from their sources. Higher concentrations of banned pesticides such as hexachlorobenzene and hexachlorocyclohexane during 2007 compared to 2006 may be due to higher volatilization rates correlated with an El Nino event during the same period. All pesticides had higher levels during the growing season compared to winter, but the ratio of concentrations during the different seasons was much higher for the pesticides in current use. The four air sampling systems deployed at Egbert were evaluated for their ability to accurately measure the air concentrations of CUPs, and their individual suitability for use in air monitoring programs will be discussed. *Keywords: Transportation, Atmospheric circulation, Pesticides.*

HEBERT, C.E.[1], PATERSON, G.[2], WESELOH, D.V.C.[3], and WHITTLE, D.M.[4], [1]Environment Canada, National Wildlife Research Centre, Ottawa, ON, K1A 0H3; [2]University of Windsor, Great Lakes Institute for Environmental Research, Windsor, ON, N9B 3P4; [3]Environment Canada, Canadian Wildlife Service, Downsview, ON, M3H 5T4; [4]Emeritus Scientist, Fisheries and Oceans Canada, Burlington, ON, L7R 4A6.
Great Lakes Pelagic Prey Fish Declines and Impacts on Top Avian and Fish Predators.

The Laurentian Great Lakes form the largest freshwater ecosystem in the world and support diverse biotic communities. However, anthropogenic stressors have altered the structure of Great Lakes' food webs. By the 1960s, over-fishing and exotic species introductions had resulted in the decline of native Great Lakes piscivorous fish, especially lake trout (Salvelinus namaycush). In order to reduce burgeoning prey fish populations occurring in the absence of a top predator, fish stocking programs were initiated that introduced Pacific salmonines into the lakes. As intended, these stocked predators reduced prey fish populations. However, the reduction in prey fish abundance has had unforeseen consequences for other members of the biotic community. Here, we present results from long-term monitoring of top trophic level seabirds and fish that reveal alterations in energy and nutrient flow over time. Seabird diets reflect alterations in prey fish abundance across the Great Lakes basin. Similarly, lake trout growth and condition metrics show signs of stress related to declines in prey availability. The changes documented here indicate that top avian and fish predators are experiencing serious energetic and nutritional constraints. These constraints are likely having population-level impacts. *Keywords: Great Lakes basin, Ecosystem health, Wildlife, Avian ecology.*

HEDGES, K.J., MANRDAK, N.E., KOOPS, M.A., and JOHANNSSON, O.E., Great Lakes Laboratory for Fisheries and Aquatic Sciences, 867 Lakeshore Road, Burlington, ON, L7R 4A6.
If You Build It, Will They Come (or Stay)? Summary and Assessment of Great Lakes Aquatic Protected Areas.

Fishes and their habitats receive various levels of protection at sites throughout the Great Lakes. Ecosystem-level management strategies can use Aquatic Protected Areas (APAs) to buffer against over-exploitation and uncertainty in population assessments and ecological understanding, and to protect aquatic habitats. Given current levels of decline in freshwater fish biodiversity and the relative importance of habitat loss in the imperilment of many fish species in and around the Great Lakes, the appeal of precautionary ecosystem-level management is increasing. To determine the types and amounts of protection afforded to fishes and their habitats, we created an inventory of APAs in the Great Lakes and connected waters used by Great Lakes fishes, including sites in both Canada and the U.S. Latitudinal trends in APA size and number were apparent, with fewer, larger sites at higher latitudes. The relative effectiveness of different types of APAs was examined using time series data, and by comparing communities within and outside APAs. Fish biodiversity was typically higher within areas that permanently protect fish habitats, although a latitudinal trend in species richness was also apparent. Finally, a Gap Analysis was conducted to identify species and habitats that are currently under-represented within the current APA network. *Keywords: Refugia, Protected areas, Conservation, Ecosystems.*

HENRY, M.[1], WANG, Y.S.[2], MCCLELLAND, G.B.[3], and WILKIE, M.P.[1], [1]Department of Biology, Wilfrid Laurier University, Waterloo, ON, N2L 3C5; [2]Department of Biology, Queen's University, Kingston, ON, K7L 3N6; [3]Department of Biology, McMaster University, Hamilton, ON, L8S 4K1.
Differences in the responses of larval and upstream migrant sea lampreys (Petromyzon marinus) to the lampricide 3-trifluoromethyl-4-nitrophenol (TFM).

The lampricide, TFM, is added to streams infested with larval sea lampreys to control populations of these invasive pests in the Great Lakes. We have demonstrated that TFM depletes brain glycogen energy reserves leading to death in larval lampreys. Little is known about TFM toxicity after lampreys have completed metamorphosis, which leads to development of an oral disc for blood-feeding, tidally ventilated gills, and increased metabolic rate. We exposed parasitic and upstream migrant lampreys to lethal doses of TFM (12h LC99.9=5 mg/l) to determine if it had similar effects on tissue (brain, liver, muscle) energy stores as in larval lampreys. Unlike larval lampreys, TFM did not alter brain ATP or phosphocreatine energy stores, but did result in 30% reductions in glycogen. Thus, unlike in larvae, glycogen depletion may not cause death in upstream migrant lampreys exposed to TFM. However, 3-6 fold increases in lactate concentration were observed in tissues of upstream migrant lampreys. Because metabolic acid is generated with lactate due to glycogen breakdown, we are testing the hypothesis that TFM decreases tissue pH which could contribute to death in upstream migrant lampreys. Our findings therefore suggest that the mechanism of TFM toxicity could reflect the sea lamprey's life history stage. *Keywords: Fish, Sea lamprey, Pesticides, Toxicology, Invasive species, Lampricide.*

HENSLER, S.R.[1], JUDE, D.J.[1], WANG, Y.[2], and JANSSEN, J.[2], [1]School of Natural Resources and Environment, University of Michigan, 440 Church Street, Ann Arbor, MI, 48109; [2]Great Lakes WATER Institute, University of Wisconsin - Milwaukee, 600 East Greenfield Avenue, Milwaukee, WI, 53204.
Offshore Larval Fish Distribution in the Great Lakes.

Relatively little is known about fish spawning and larval fish ecology in the offshore regions of the Great Lakes compared to the knowledge base for fishes inhabiting warmer, shallower habitats. Larval fish were collected while conducting vertical net tows of the entire water column at night as well as some horizontal, near surface tows during April and August 2007 and 2008 in association with the U. S. EPA Biological Monitoring Program on the Great Lakes as well as other larval fish collections of the mid-lake reef complex in Lake Michigan. Unexpected collections of newly-hatched larval fishes included two burbot (Lota lota), one round whitefish (Prosopium cylindraceum), and one bloater (Coregonus hoyi) at two deep sites, one in southern Lake Michigan and the other in northern Lake Huron, months later than previously reported for yolk-sac larvae for these species. These findings suggests that burbot and coregonines inhabiting the abyssal regions of the Great Lakes may be separate, reproductively isolated populations from shallow spawning members of the same species. More larval fish research is warranted, particularly for offshore and abyssal sites in the Great Lakes, as detailed, fundamental spawning and early life history knowledge about fishes inhabiting these areas remains a mystery of the deep. *Keywords: Spatial distribution, Distribution patterns, Fish.*

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HERBST, S. and MARSDEN, J.E., Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington, VT, 5405.
Comparison of Lake Champlain and Great Lakes lake whitefish populations following the introduction of dreissenids.

Recent declines in lake whitefish growth and condition in the Great Lakes have been attributed to introduction of dreissenid mussels in the Great Lakes, and the disappearance of Diporeia, a once-abundant, high energy prey source. Lake Champlain, similar to the Great Lakes, has experienced the introduction and proliferation of zebra mussels, but in contrast, Diporeia were not historically abundant. Our goals were to quantify seasonal diet, growth, and condition of whitefish in Lake Champlain and compare those results to data from the Great Lakes following the invasion of dreissenids. Whitefish were collected using gillnets and bottom trawls. Diet was quantified seasonally and expressed as percent composition. Condition was estimated using Fulton's K and von Bertalanffy growth parameters were calculated. Lake Champlain whitefish, unlike whitefish from the Great Lakes, have not shown a dietary shift towards zebra mussels, but instead are feeding primarily on fish eggs in spring, Mysis relicta in summer, and gastropods in fall. Population trends over time are unknown because of the paucity of historic data; however, growth and condition of Lake Champlain whitefish does not appear to have declined since a 1930 study. Whitefish diets and growth in Lake Champlain do not appear to have been impacted by the zebra mussel invasion. *Keywords: Invasive species, Dreissena, Lake whitefish, Fish diets.*

HESLIP, L.D.[1] and STRUGER, J.[2], [1]#905 - 3165 Russell St, Windsor, ON; [2]Environment Canada, Box 5050, Burlington, ON, L7R 4A6.
A Comparison Between Substitution and Survival Techniques for Analyzing Censored Data.

Three organic compounds (Atrazine, 2,4-Dichlorophenoxyacetic acid (2,4-D), and Chlorpyrifos) sampled from a long term site (Vineland Creek) located in southern Ontario were examined to determine the effect of including and removing censored observations in trend analysis. Two methods of analysis were used to assess the inclusion and removal of censored observations. The first method substituted censored observations with ½ the method detection limit (MDL). The second method involved analyzing censored observations with survival analysis techniques, where observations below the MDL were treated as censored data. Atrazine ($< 20\%$) and 2,4-D ($< 2\%$) had fewer censored data, while over half ($> 57\%$) of the samples collected for Chlorpyrifos contained censored data. Trend analyses were conducted for the substitution and survival methods by using generalized linear model (GLM) regression and the LIFEREG procedure, respectively. The results of the substitution and survival methods were compared to illustrate the differences between the regression results. To further illustrate the differences between the results of the substitution and survival analysis methods, censored observations were artificially created for Atrazine and 2,4-D, such that at least 50 percent of the observations were censored data. *Keywords: Organic compounds, Pesticides.*

HICKEY, M.B.C. and RIDAL, J.J., St. Lawrence River Institute of Environmental Sciences, 2 Belmont St, Cornwall, ON, K6H 4Z1.
Addressing the Fish Consumption Beneficial Use Impairment in the Bay of Quinte.

We assessed the state of contamination in Bay of Quinte (BoQ) fish to determine whether delisting criteria have been met, and to recommend further studies/actions to be undertaken. We examined fish contaminant data collected by the Ontario Sport Fish Monitoring Program between 1975 and 2005 for seven sites in Lake Ontario and the BoQ. Our analysis included mercury, PCBs, DDT and DDE, and dioxins and furans, and compared contaminant concentrations in fish among sites as a function of fish length. While there were no significant differences for the majority of contaminants, some species and contaminant combinations at one or more of the BoQ sites were elevated compared to reference sites. For instance, levels of mercury in walleye and PCBs in chinook salmon from BoQ sites exceeded those from reference sites. However, these fish species are large, long-lived and potentially wide-ranging and it is difficult to conclusively link elevated levels to local sources. Consumption restrictions for more sentinel fish (e.g. brown bullhead) are more severe for fish from the Upper Bay compared to the other sites, suggesting possible impacts of local sources. As a result, the fish consumption beneficial use continues to be classified as impaired for the BoQ. A sentinel fish monitoring program is underway to track local contaminant sources. *Keywords: Bay of Quinte, Pollution sources, Fish toxins.*

HIGGINS, S.N.[1] and HOWELL, E.T.[2], [1]Center For Limnology, University of Wisconsin-Madison, 680 N. Park Street., Madison, WI, 53706, United States; [2]Ontario Ministry of the Environment, 125 Resources Road, Toronto, ON, M9P 3V6.
The current status of Cladophora blooms along the northern coastline of Lake Ontario.

The Laurentian Great Lakes have a long history of problems associated with massive blooms of the nuisance alga *Cladophora glomerata*. Here, we report the status of Cladophora blooms and their relationship to water quality variables from 4 sites along the northern coastline of Lake Ontario during the Lake Ontario bi-national cooperative monitoring year (2008). At each of the 4 survey areas data were collected from 2 transects at multiple depths (approx. 3, 6, 10, 18m) utilizing SCUBA during the early- (June) and mid-summer (July) periods. Cladophora filaments were present at all sites and depths sampled, with areal coverage ranging from 5 to 100% (mean= 74.9 ± 30.5 %) during the July period. Biomass was strongly depth dependant, ranging from 59.0 ± 32.6 g DM/m^2 at shallow sites (2-5m) to 5.1 ± 5.2 g DM/m^2 at the deepest (17-18m) sites. Sites adjacent to highly urbanized areas had biomass levels 2-3 times higher than sites adjacent to areas with low urbanization. These data suggest that Cladophora blooms are widespread across rocky sites in Lake Ontario, that background nutrient concentrations are sufficient to promote nuisance growth, and that nutrient concentrations associated with urbanization can exacerbate growth leading to severe blooms conditions (>50 g DM/m^2). *Keywords: Eutrophication, Dreissena, Cladophora, Algae.*

HILDITCH, T.W.[1] and HORTON, M.[2], [1]58 Welstead Drive, St. Catharines, ON, L2S 4B2; [2]St. Mary's Cement/CBM, 55 Industrial Street, Toronto, ON, M4G 3W9.
Presqu''ile Bay Species at

Risk Outreach Project Case Study In Endangered Species Act, 2007 Stewardship & Outreach Tom Hilditch1, Melanie Horton2 1 Savanta Inc., 2 St Marys Cement.

Stewardship aspects of the Ontario Endangered Species Act, 2007, led to a project on 4 linear km of coastal wetlands owned by St Marys Cement in Presqu'Ile Bay, Ontario. St Marys Cement, the largest cement producer in the Great Lakes Region and the Province of Ontario jointly funded work between 2007 and 2009, which led to a SAR Conservation and Management Plan, a Vegetation Management Plan and a Draft Research Strategy. Technical studies revealed the presence of an unexpectedly high population of Least bitterns (Threatened) and King rail, (Endangered) on these private lands and more broadly in Presqu'Ile Bay. Building on work completed, a feasibility study is currently investigating the creation of a SAR Centre of Excellence on the St Marys Cement lands in Presqu'Ile Bay. This Centre could become a substantial hub for outreach and education activities and would ensure the conservation of important populations of waterbirds. The centre would also serve to inspire greater private sector investment in Great Lakes wetland conservation. This work has already become a model of stakeholder engagement and outreach, gaining the energies and support of many stakeholders including the Municipality of Brighton, Friends of Presqu'ile Park, Northumberland Stewardship Council, Lower Trent Conservation Authority and SAR Recovery Teams. *Keywords: Outreach, Endangered, Coastal wetlands, Threatened, Lake Ontario.*

HILL, R.B., Environment Canada, 867 Lakeshore Road, Burlington, ON, L7L 6V7, Canada. **Long Term Contaminant Trends From The Niagara River.**

In the wake of Love Canal and a series of reports on contamination issues in the Niagara River, a formal water quality monitoring program was established in 1986 as part of the Niagara River Toxics Management Plan (NRTMP). One of the primary goals of the NRTMP was to "achieve significant reductions of toxic chemical pollutants in the Niagara River" and the "Upstream/Downstream Program" provides a means of quantifying remedial action success at point sources, hazardous waste sites and SuperFund sites along the river. The Program's focus on dissolved and particulate phase analysis also helps to establish the existence and relative concentrations of contaminants, distinguish between Niagara River contaminant sources and upstream sources, identify exceedences to existing water quality criteria, and quantify loadings of these contaminants to Lake Ontario. Analysis of Upstream/Downstream Program data taken from a 19 year period between 1986/87 and 2004/05 show a significant decrease in concentration for most compounds - including the NRTMP's "Priority 18". Analysis also shows that while local sources continue to contribute to contaminant levels in the Niagara River, upstream and Great Lakes basin-wide sources may be more significant for certain chemicals. *Keywords: Niagara River, Water quality, Monitoring.*

HILL, S.[1], EDGE, T.[1], SETO, P.[1], MARSALEK, J.[1], D'ANDREA, M.[2], BOWERING, T.[2], SNODGRASS, W.J.[2], and STINSON, G.[2], [1]Environment Canada, 4905 Dufferin Street, Toronto, ON, M3H 5T4; [2]City of Toronto, Toronto Water, Metro Hall, 55 John Street, 18th Floor, Toronto, ON, M5V 3C6. **Microbial source tracking to identify sources of fecal pollution contaminating Toronto beaches and rivers.**

This paper summarizes results from the application of microbial source tracking tools to identify the sources of fecal pollution contaminating Toronto beaches and the Humber and Don Rivers. These tools included antibiotic resistance analysis and DNA fingerprinting of E. coli isolates, and assays to detect DNA sequences that are unique to bacteria from the human or seagull gut. Application of these tools has been able to identify the significance of waterfowl fecal droppings at some beaches, and to identify specific stormwater outfalls and other sources of sewage contamination in the Humber and Don River watersheds. *Keywords: Pollution sources.*

HINCH, S.G.[1], COOKE, S.J.[2], FARRELL, A.P.[3], and PATTERSON, D.A.[4], [1]Forest Sciences Department, University of British Columbia, Vancouver, BC, V6T1Z4; [2]Institute of Environmental Science, Carleton University, Ottawa, ON, K1S5B6; [3]Land and Food Systems, University of British Columbia, Vancouver, BC, V6T1Z4; [4]Canadian Department of Fisheries and Oceans, Simon Fraser University, Burnaby, BC, V5A1S6.
Linking Telemetry, Physiology, And Experimental Biology: Novel Approaches For Use In Studying Salmonid Migrations And Managing Fisheries.

Salmonid migrations represent one of the most complex and intriguing biological phenomena in the animal kingdom. Telemetry has been used extensively to describe movement and survival patterns associated with these migrations but by itself cannot inform the mechanisms underlying behaviour or causes of mortality. We summarize advances that have been made in understanding the migrations of adult Pacific salmon through the integration of broad-scale telemetry systems, including POST and OTN systems, with disciplines including physiology, behaviour, functional genomics, and experimental biology. Record high temperatures, changing ocean conditions, disease, fisheries and other factors are threatening several populations, and challenging management systems. We overview intervention experiments and field approaches used to examine these issues and explore hypotheses about recent changes in salmon behaviour and mortality. We have identified roles that fish health, physiological and reproductive state, physiological stress, and fisheries handling have on migration behaviour and survival. Our approaches have uncovered fascinating insights into the basic biology of salmonids, as well as generated important information for use by fisheries managers in dealing with climate warming and capture-release fisheries. *Keywords: Migrations, Physiology, Salmon, Experimental biology, Fish management, Telemetry.*

HINDLEY, B.[1], GORHAM, B.[2], BOWEN, G.[2], LIANG, W.[3], and SNODGRASS, W.J.[3], [1]Aquafor Beech Limited, 2600 Skymark Avenue, Building 2, Suite 202, Mississauga, ON, L4W 5B2; [2]Toronto and Region Conservation, 5 Shoreham Drive, North York, ON, M3N 1S4; [3]City of Toronto, Metro Hall, 55 John Street, 18th Floor, Toronto, ON, M5V 3C6.
Time – trend Analysis of constituents in Water Courses Discharging to the Toronto AOC over the past 4 decades.

An analysis has been undertaken to document the time- trend of key constituents in water courses discharging to Toronto's waterfront. The analysis indicates that there are only a few key constituents which show trends over the past 3 -4 decades – mainly total phosphorus and

chlorides (and conductivity). Changes in analytical methods and detection limits limit the analysis for constituents such as metals (copper, zinc, lead), and mask our ability to draw conclusion about these substances, even considering that lead removal from gasoline should have lead to approximately an order or magnitude decrease in this constituent. The most pronounced effect in total phosphorus is a several fold decrease associated with removal of small wastewater treatment plant effluents from discharging to water courses in the 1960's, the addition of phosphorus control to wastewater treatment plants and the removal of phosphorus from detergents in the 1970's. Chloride trends are increasing in watersheds subject to urbanization, but relatively level (i.e. non $-$ increasing) in watersheds such as the Don River which have been dominated by a mature road network. This analysis suggests that a chronic level of impairment has been reached,supporting delisting of the applicable BUI's. *Keywords: Phosphorus, Urbanization, Nutrients.*

HITES, R.A. and VENIER, M., School of Public and Environmental Affairs, Indiana University, Bloomington, IN, 47405, United States. **Harmonic Fitting of Atmospheric POPs' Concentrations Measured Near the Great Lakes Over the Last 17 Years.**

One of the challenges in tracking the atmospheric concentrations of POPs is accounting for all of the sources of variation such that changes in these concentrations resulting from the elimination of sources can be teased out from other variations. We have previously identified time (as Julian Days, JD), local human population (POP), and seasonality (expressed as atmospheric temperature) as the most important factors in determining the atmospheric concentrations of POPs. Most recently, we have combined these parameters into a single harmonic equation of the form: $\ln(C) = a_0 + a_1 JD + a_2 \sin(z\,JD) + a_3 \cos(z\,JD) + a_4 \log^2(POP)$, where $z = 2\pi/365.25$. Each parameter is associated with a partial sum of squares that indicates the importance of that parameter in the overall regression. The regression was applied to vapor, particle, and precipitation concentrations of several POPs measured by the Great Lakes' Integrated Atmospheric Deposition Network every 12 days since 1992. This approach allows us to fit both vapor and particle phase concentrations and to determine when these concentrations maximize. Most vapor phase concentrations maximize in mid-summer, and most particle phase concentrations maximize in mid-winter. *Keywords: PBDEs, Organochlorine compounds, PCBs.*

HOEKSTRA, P.F. and HARRINGTON, C.R., Syngenta Crop Protection Canada, Inc., 140 Research Lane, Guelph, ON, N1G4Z3. **The Environmental Safety of Pesticides: An Industry Perspective.**

Pesticides are a valuable tool in modern agriculture and in controlling invasive species. The proper use of these compounds promotes human health by providing an abundant, high quality and affordable food supply for our growing population. Unfortunately, information reported in the media often portrays to the general public that pesticides are poorly regulated or not rigorously tested. In reality, the Canadian pesticide industry is stringently regulated by the Health Canada as mandated under the Federal Pest Control Products Act. Before a pesticide product can be legally sold and used in Canada, it undergoes a comprehensive suite of

environmental testing (e.g., environmental toxicology, fate parameters) and scientific assessment to ensure it does not pose an unacceptable risk to non-target organisms. During this presentation, various aspects of the Canadian regulatory process, with emphasis on the environmental effects of pesticides, will be discussed. Important aspects to consider when designing post-registration monitoring or research programs will also be presented. *Keywords: Pesticides, Regulatory, Risk assessment, Macroinvertebrates.*

HOLEM, R.R.[1], ROARK, S.A.[1], NEWSTED, J.[1], MATOUSEK, J.[1], GIESY, J.P.[2], and KAY, D.P.[1], [1]ENTRIX, Inc., Okemos, MI, 48864; [2]University of Saskatchewan, Saskatoon, SK, SK S7N.
Evaluation of Spatial Variation in Tetrachlorodibenzo-*p*-dioxin Equivalents From Dioxins, Furans, and Polychlorinated Biphenyls in Fillets of 10+ Fish Species Collected From the Saginaw Bay Watershed, Michigan, USA.

Concentrations of dibenzo-p-dioxins, dibenzofurans, and dioxin-like polychlorinated-biphenyls were measured in fillets of nearly 1000 fish collected from seven locations on the Tittabawassee and Saginaw Rivers, the Saginaw Bay, and four other rivers within the Saginaw Bay watershed. Tetrachlorodibenzo-p-dioxin equivalents (TEQ) and the concentration of the sum of each class (ΣTEQ) of congeners were compared. Concentrations were generally greatest in carp and channel catfish while lipid-normalized concentrations were greatest in smallmouth bass. In those species, ΣTEQPCB composed about 70% of the ΣTEQtotal at upstream locations, and ranged from 40% to 70% of the ΣTEQtotal in the Tittabawassee and Saginaw Rivers. Spatial variation was generally the greatest for ΣTEQPCDF and the least for ΣTEQPCB. The maximum difference in tissue concentration between collection locations was 4- to 11-fold for ΣTEQPCB, 5- to 8-fold for ΣTEQPCDD, and 25- to 48-fold for ΣTEQPCDF. Variation in concentrations was greatest in smallmouth bass and least in carp. For ΣTEQPCB in carp, there were few statistically significant differences between locations, whereas for ΣTEQPCDF in carp nearly all comparisons of upstream with either Tittabawassee or Saginaw River locations differed significantly. *Keywords: Tittabawassee, Lake Huron, PBTs, Fish.*

HOLSEN, T.M.[1], HOPKE, P.K.[2], AMOS, M.M.[3], MILLER, K.M.[3], TELECH, J.T.[3], SCHOFIELD, J.A.[3], MILLIGAN, M.S.[4], MURPHY, E.W.[5], and PAGANO, J.J.[6], [1]Clarkson University, Department of Civil and Environmental Engineering, Potsdam, NY, 13699; [2]Clarkson University, Department of Chemical Engineering, Potsdam, NY, 13699; [3]Computer Sciences Corporation (CSC), 6101 Stevenson Avenue, Alexandria, VA, 22304; [4]SUNY Fredonia, Department of Chemistry, Fredonia, NY, 14063; [5]U.S. EPA Great Lakes National Program Office, 77 West Jackson Boulevard, Chicago, IL, 60622; [6]SUNY Oswego, Environmental Research Center, Oswego, NY, 13126.
Legacy and Emerging Contaminant Concentrations in Great Lakes Fish Between 1991 and 2008 and Evaluation of Differences Between Sampling Sites.

U.S. Environmental Protection Agency's Great Lakes National Program Office funds and administers the Great Lakes Fish Monitoring and Surveillance Program. This program focuses on monitoring contaminant trends in the open waters of the Great Lakes (using fish as biomonitors). Direct comparison of contaminant concentrations across lakes is not possible as

the program was designed to analyze fish of similar size, rather than of the same age. For this reason, only general chemical concentration patterns can be observed. Statistical tools and GIS were used to evaluate differences in time trends among sites for a suite of legacy and emerging contaminants, including PBDE congeners, PCB congeners, mercury, and pesticides. Trends for contaminant concentrations in lake trout and walleye in the Great Lakes were assessed from 1991 to 2008. Results suggest that trends for several contaminants are similar among several sites and different between other sites. Time trends among the legacy and emerging contaminants are similar for several contaminants and different for other contaminants. Statistical analyses also are being applied to assess the differences and describe the relationships among the sites and contaminants. These assessments may provide clues to identification of the sources and pathways of these contaminants to Great Lakes fish. *Keywords: Environmental contaminants, Chemical analysis, Fish.*

HOOD, J.L.A., TAYLOR, W.D., and SCHIFF, S.L., University of Waterloo 200 University Ave W, Waterloo, ON, N2L 3G1. **Urban waste water effluent has an impact on benthic macrophyte communities even in a heavily agricultural watershed: Going beyond TP/biomass relationships.**

Benthic macrophyte communities are key to riverine environments. They provide complex habitat and food for river inhabitants across multiple trophic levels, additionally they modify the river environment by augmenting flow and sedimentation rates and changing the dissolved chemistry. In many rivers macrophyte biomass can reach nuisance levels leading to the development of night time hypoxia. Many researchers agree that nuisance levels of biomass are a result anthropogenic nutrient enrichment, however drawing empirical relationships between biomass and nutrients has been difficult. This is because macrophyte communities are likely to be space, substrate and light limited, particularly in upstream locations. Additionally there is a spatial disconnect between the location of the macrophyte bed and the source of it's nutrient. The lack of an empirical link has complicated modeling efforts and hindered riverine eutrophication management. Through studies conducted by the Grand River Conservation Authority and our lab group demonstrate the enriching effect of sewage treatment plants on macrophyte biomass in the Grand River, the largest Canadian tributary to lake Erie. We also show how this effect can be obscured by the use a simple linear regression and make suggestions for how macrophyte modeling efforts can be improved. *Keywords: Spatial distribution, Macrophytes, Eutrophication, Hypoxia.*

HORDOWICK, J., DHALLA, S., IVEY, J., and MEEK, S., Toronto and Region Conservation, 5 Shoreham Drive, Downsview, ON, M3N 1S4. **An Integrated Modelling Approach used to Identify 'Best Bet' Areas for Stormwater Retrofits and Low Impact Development Techniques in the Don River Watershed.**

The Don River Watershed faces major challenges including aging or inadequate stormwater infrastructure, limited natural cover and the pressures of a growing population. The recently completed Don River Watershed Plan integrates stormwater modelling with data on fish habitat, stream erosion potential, natural heritage and flood risk to prioritize future restoration

efforts. Two scenarios were examined in the development of management recommendations. The future conventional scenario modelled the watershed impacts of approved development and intensification using existing stormwater management practices; the future 'sustainable communities' scenario modelled the same build out with aggressive implementation of low impact development (LID) practices (i.e. green roofs, rainwater harvesting, permeable pavement) and expanded urban forest in new and existing urban areas. To better understand the possible future conditions, the study also examined existing conditions and trends in the watershed, reviewed research and consulted a wide range of experts. This integrated approach led to identification of priority basins for LID retrofit practices in the upper Don to complement the City of Toronto's Wet Weather Flow Management Master Plan recommendations for the lower Don, giving a picture of 'best bet' priorities across the watershed. *Keywords: Low Impact Development, Urban watersheds, Retrofit.*

HORST, G.P. and SARNELLE, O., Department of Fisheries and Wildlife, Michigan State University, East Lansing, MI, 48824.
Nitrogen limitation, but not *Dreissena* grazing, affect microcystin quota of *Microcystis aeruginosa*.

A main objective in managing harmful algal blooms is determining what factors influence the toxicity of bloom-forming species. Most research on environmental factors has been limited to laboratory experiments with cultured algal strains. We conducted a large-scale field experiment (30 enclosures; 31,000 L each) in oligotrophic Gull Lake to examine the effects of nutrient addition and zebra mussels on the production of microcystin (a potent liver toxin) by the cyanobacterium *Microcystis aeruginosa*. We followed this with a lab experiment using a strain of *M. aeruginosa* isolated from Gull Lake. Both experiments showed that N-limited conditions reduced microcystin quota. Data from an extensive field survey in the western basin of Lake Erie were congruent with these results in that there were negative relationships between nitrate concentration and microcystin per unit biomass of *M. aeruginosa*. Our results are consistent with the hypothesis that production of N-rich secondary metabolites, such as microcystin, should be reduced disproportionately by N limitation. *Keywords: Phytoplankton, Microcystis, Nutrients.*

HOSSAIN, M.[1], ARHONDITSIS, G.B.[1], MINNS, K.[2], and KOOPS, M.[2], [1]University of Toronto, Toronto, ON; [2]Fisheries and Oceans Canada, Great Lakes Lab Fisheries and Aquatic Sciences, Burlington, ON.
Examination of Ecosystem Management Options in Hamilton Harbour using Food Web Modeling.

Hamilton Harbour is an embayment at the western tip of Lake Ontario. The Harbour was identified as one of the most polluted sites in the Great Lakes by the Water Quality Board of the International Joint Commission in 1985. As a consequence, a multidisciplinary environmental remedial action plan (RAP) to restore the ecosystem health and to maintain the integrity of the local biotic communities has begun. However, the recent invasion of zebra mussels and round goby in the system has called into question the RAP's target to successfully create a sustainable, self–reproducing native fish community. To assess the potential for success of the RAP's targets in the areas of fish and wildlife habitat restoration, an energy budget model has been developed

using the Ecopath with Ecosim software. Our primary research questions are to examine: (1) to what extent the ecosystem functioning has been transformed by the significant anthropogenic disturbances and the subsequent restoration efforts, and (2) how realistic is the goal to alter the current Harbour ecological state and to meet the objectives of the Hamilton Harbour and Watershed Fisheries Management Plan. Our analysis also argues that any further water quality improvements in the system should be viewed in the context of a combined bottom-up and top-down control. *Keywords: Mathematical models, Ecopath with Ecosim, Fisheries, Hamilton Harbour, Fish management, Food web dynamics.*

HOWELL, E.T.[1] and MAKAREWICZ, J.C.[2], [1]Environmental Monitoring and Reporting Branch, Ontario Ministry of the Environment, Toronto, ON, M9P 3V6; [2]The College at Brockport, SUNY, Brockport, NY; **Water Quality on the Shores of Lake Ontario in 2008.**

Multifaceted monitoring of the nearshore of Lake Ontario in 2008 provides insight on conditions in this dynamic and changing environment. Aproximately 85 km of shoreline over four segments varying in land-use was surveyed. Sharp gradients in water quality were observed from the land to the open lake. In contrast to total phosphorus concentrations of <10 μg L^{-1} over most of the nearshore, elevated levels were periodically observed at the shoreline, tributary mixing areas and some outfalls. Tributaries near the lakeshore were often turbid, with elevated levels of solids and nutrients. The extent to which tributary discharge affected the shores of the lake varied widely. Features of land-to-offshore gradients in total phosphorus among areas suggested regional differences in nutrient richness. Modification of the nearshore lakebed by dreissenid mussels and benthic algae has been extensive. In 2008 *Dreissena* covered approximately 47% of lakebed. Yet unlike previous surveys, little correspondence was observed between water clarity and locations of anticipated high grazing rates such as over rock shoals. Wide variability in water clarity and levels of particulates in the water column was observed driven by combinations of upwelling, shoreline-lakebed disturbance, runoff and whiting. *Keywords: Coastal ecosystems, Water quality, Monitoring.*

HOYLE, J.A.[1], BOWLBY, J.N.[1], JOHNSON, T.B.[1], MORRISON, B.J.[1], BROUSSEAU, C.M.[2], and RANDALL, R.G.[2], [1]Ontario Ministry of Natural Resources, 41 Hatchery Lane, Picton, ON, K0K 2T0; [2]Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Bay of Quinte Fish Populations: The Influence of Nutrient Levels and Invasive Species on Community Structure.**

Long-term sampling in the Bay of Quinte with multiple gear types allowed examination of the fish community and major fish populations in the context of key stressors up to 2009. Excessive nutrient input and hyper-abundant exotic fish species shaped the depreciated fish community of the 1970s. After implementation of phosphorus input control measures and simultaneous "winter-kills" of the hyper-abundant exotics in the late-1970s, walleye recovered and served to restore predator prey balance to the fish community by the late-1980s. But, in the absence of a significant recovery of submerged aquatic vegetation in littoral areas, off-shore species still tended to dominate littoral areas. Water transparency increased and submerged aquatic vegetation recovered over broad littoral areas soon after the invasion of dreissenid

mussels in the mid-1990s. This pivotal event led to a shift in the fish community that included an overall decline in walleye abundance, an increase followed by a decrease in yellow perch abundance, a delayed increase in white perch abundance, and a dramatic shift in the nearshore fish community to one dominated by centrarchids (i.e. bluegill, pumpkinseed, black crappie and largemouth bass) dependent upon aquatic vegetation. Round goby invaded in 1999, proliferated and became important in the diet of piscivores. *Keywords: Bay of Quinte, Invasive Species, Fish populations, Nutrient Levels, Lake Ontario, Fish community.*

HOYLE, J.A.[1], JOHANNSSON, O.E.[2], and BOWEN, K.L.[2], [1]Ontario Ministry of Natural Resources, 41 Hatchery Lane, Picton, ON, K0K 2T0; [2]Fisheries and Oceans Canada, 867 Lakeshore Rd, Burlington, ON, L7R 4A6. **Lake Whitefish (*Coregonus clupeaformis*) Early Life History Studies on the Bay of Quinte, Lake Ontario.**

In this paper, we describe larval lake whitefish (*Coregonus clupeaformis*) early life history studies conducted in several years over the course of two decades (1991-1993, 1995-1996 and 2003-2005) on the Bay of Quinte, Lake Ontario. The larval fish were captured in shallow, nearshore waters as early as Mar 27 and as late as May 19 with water temperatures ranging from 1.2-18.6 ^{o}C (mean = 8.3 ^{o}C). Mean fish length ranged from 13.6-23.9 mm (mean = 16.4 mm). Growth in length accelerated as water temperatures rose above 10 ^{o}C. Larval lake whitefish fed primarily on cyclopoid copepods and small-bodied cladocerans. Cyclopoid copepods declined by nearly an order of magnitude (86% by weight) from the earlier (1992-1996) to the later (2003-2005) sampling periods. The larval fish were selective with respect to prey size but smaller cyclopoid copepods were selected in the latter sampling period when prey density was much lower. Mean copepod prey sizes were 0.72 mm in the earlier time period and 0.57 mm in the later years while mean sizes available were 0.49 and 0.45, respectively. *Keywords: Cyclopoid copepods, Lake Ontario, Larval lake whitefish, Life history studies, Bay of Quinte, Dreissenid mussels.*

HU, D. and HORNBUCKLE, K.C., Department of Civil and Environmental Engineering, The University of Iowa, Iowa City, IA, 52242. **3, 3'-Dichlorobiphenyl in Lake Erie and Lake Ontario Sediment Cores.**

The PCB congener, congener 3, 3'-dichlorobiphenyl or PCB11, was not present as part of the banned Aroclor mixtures. However, it was recently reported in air samples collected in Chicago, Philadelphia, Cleveland, the Arctic, and several sites around the Great Lakes. In Chicago, PCB11 was found to be the fifth most concentrated congener and ubiquitously distributed throughout the urban-industrial complex. More recently, we have found that PCB11 is originated from current commercial coloring pigments. The pigments are widely used in various applications such as paint, inks, textiles, paper, cosmetics, leather, plastics, food and many other materials. Our findings also suggest that current commercial paint is an important source to atmospheric PCBs. In this study, we analyzed archived sediment cores from Lake Erie and Lake Ontario for PCB11 and other PCB congeners. The Lake Erie core represented sediment deposited from 1974 at the bottom of the core to the sampling year of 2003. The Lake Ontario sediment core spanned a much larger time period which extended to the time prior to the

production of PCBs. Based on our measurement of PCBs in these archived sediment samples, we attempted to shed light on the temporal trends and characterization of emission sources of PCB11 accumulation in the Great Lakes. *Keywords: Lake Erie, 3, 3'-Dichlorobiphenyl, Lake Ontario, Sediment, PCBs.*

HUANG, J.[1], CHOI, H.D.[1], HOPKE, P.K.[2], and HOLSEN, T.M.[1], [1]8 Clarkson Ave., Potsdam, NY, 13699-5712; [2]8 Clarkson Ave., Potsdam, NY, 13599-5708.
Ambient Mercury Sources in Rochester, NY: Results from Principle Component Analysis (PCA) of Mercury Monitoring Network Data.

Continuous airborne measurements of speciated mercury (Hg) (elemental mercury (Hg^0), reactive gaseous mercury (RGM), and particulate mercury (Hg_p)) were made in Rochester, NY from Dec 07 to May 09. Continuous measurements of ozone (O_3), sulfur dioxide (SO_2), carbon monoxide (CO), particulate matter ($PM_{2.5}$), and meteorological data were made by New York department of environmental conservation (NYDEC). A principle component analysis (PCA) of 3886 observations of 13 variables for the period from Dec 07 to May 09 identified 8 factors. Ther were snow-melting, coal-fired facilities, gas-phase oxidation, wet deposition, low ozone, clean air, liquid phase reduction, and combustion. Conditional probability function (CPF) analysis found the factors were associated with different wind directions and suggests that the three mercury species often come from different directions. The concentrations of three mercury species from the CFPP direction were significantly reduced following the CFPP shut down. This result implies the local CFPP caused a significant impact in the downwind area. *Keywords: Pollution sources, CFPP, Monitoring, Mercury, PCA.*

HÖÖK, T.O.[1], SEPÚLVEDA, M.S.[1], and NALEPA, T.F.[2], [1]Purdue University, Dept. of Forestry and Natural Resources, 195 Marsteller St., West Lafayette, IN, 47907; [2]NOAA, Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 48108.
Mapping the condition of Diporeia.

The holo-arctic amphipod, *Diporeia* spp., historically constituted a large component of benthic invertebrate communities throughout the Great Lakes region. However, since the early 1990's, this species-group has experienced precipitous declines in abundance in not only lake Michigan, but also lakes Huron, Erie, and Ontario. While mechanisms of these declines remain enigmatic, declines have occurred coincident with establishment of invasive dreissenid mussels, suggesting that dreissenid-induced changes to lower trophic levels or alteration of lake physical properties may be contributing mechanisms. In 2008, we initiated a broad, collaborative project to 1) collect *Diporeia* spp. from throughout the Great Lakes region, 2) characterize the genetic variation and physiological condition of spatially-distinct *Diporeia* stocks, and 3) conduct a series of experiments to evaluate how *Diporeia* respond physiologically to various stressors. We will provide an overview of our project and describe patterns of *Diporeia* abundance. *Keywords: Amphipods, Diporeia, Genetics.*

ISAAC, E.J.[1], HRABIK, T.R.[1], STOCKWELL, J.D.[2], JOHANNSSON, O.E.[3], and MADENJIAN, C.P.[4], [1]Department of Biology, University of Minnesota, Duluth, MN, 55812; [2]U.S. Geological Survey, Great Lakes Science Center, Ashland, WI, 54806; [3]Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, Burlington, ON, L7R4A6; [4]U.S. Geological Survey, Great Lakes Science Center, Ann Arbor, MI, 48105. **Consumption by the Lake Superior Fish Community: How Important are *Mysis relicta*?**

Restoration and rehabilitation of native fish communities is an important goal in the Laurentian Great Lakes, with emphasis placed on understanding food web stability. We used bioenergetics models for the major fish species in Lake Superior to estimate prey consumption at nearshore and offshore locations across Lake Superior in 2005. We also estimated the production of *Mysis relicta*, a major component of the Lake Superior food web, and compared it to fish consumption estimates to evaluate how *Mysis* is utilized in terms of demand-supply. On average, *Mysis* was the most consumed prey item at nearshore and offshore locations. Lake whitefish *Coregonus clupeaformis*, bloater *Coregonus hoyi* and rainbow smelt *Osmerus mordax* consumed the most *Mysis* at nearshore locations, while kiyi *Coregonus kiyi* and deepwater sculpin *Myoxocephalus thompsoni* were responsible for *Mysis* consumption at offshore locations. We found that the proportion of *Mysis* in relation to all prey consumed increased with depth (p = 0.007). The demand-supply relationship was balanced in most respects, indicating *Mysis* resources are consumed by the current fish community without room for major expansions of other fish species that rely on *Mysis* such as other deepwater ciscoes. *Keywords: Ecosystem modeling, Mysis relicta, Lake Superior, Fisheries.*

ISELY, E.S. and STEINMAN, A.D., Annis Water Resources Institute, Grand Valley State University, 740 W. Shoreline Drive, Muskegon, MI, 49441. **Rein in the Runoff Integrated Assessment: Stormwater Management in Spring Lake (MI).**

Rein in the Runoff is a collaborative, community-based Integrated Assessment that examined the causes, consequences, and corrective alternatives available to the communities within and downstream of the Spring Lake Watershed to minimize the negative impacts of polluted stormwater runoff to local water bodies. An interdisciplinary team, consisting of ecologists, engineers, planners, economists, and lawyers, worked with stakeholders to help address management and stewardship issues regarding stormwater discharges. Our Integrated Assessment approach synthesized and delivered existing scientific information and ran modeling scenarios for future population growth, associated land use change, and the influence of best management practices to assess stormwater management alternatives. Because stakeholder involvement was essential to knowing what was important to whom and why, we engaged stakeholders in development and review of the Integrated Assessment. We anticipated that greater stakeholder involvement would also encourage broad-based approval of final outcomes. This presentation will describe Rein in the Runoff, highlighting the extent of, and the opportunities and challenges associated with, stakeholder participation throughout the process. Finally, we will explore ongoing stakeholder activities in light of project outcomes. *Keywords: Decision making, Integrated assessment, Public education, Stormwater management, Public participation, Best management practices (BMPs).*

<u>IVAN, L.N.</u> and HÖÖK, T.O., Purdue University, 195 Marstellar, West Lafayette, IN, 47905.
Modeling the impacts of zooplankton abundance on walleye and yellow perch YOY growth and survival in Saginaw Bay, Lake Huron.

Walleye and yellow perch are economically and ecologically important species in the Great Lakes. Saginaw Bay historically supported large commercial and recreational fisheries for both walleye and yellow perch, but changes in the environment have altered abundance and growth rates for both species. Food availability, and competition between larval walleye and yellow perch for zooplankton, may be responsible for slow growth and small end of the year size in yellow perch and walleye. To determine how zooplankton availability affects yellow perch and walleye growth during the first year of life, we developed an individual-based model of walleye and yellow perch populations in Saginaw Bay. The models tracks consumption, growth, and survival on a subdaily time step through one growing season. Fish grow via a modified bioenergetics subroutine and experience both predation and starvation mortality such that small individuals with low storage weights experience higher mortality rates. Simulations included varying zooplankton density and altering the timing of peak zooplankton abundance. Results from the model will be used to assess likely bottlenecks to growth of yellow perch and walleye and focus future research on these species within the bay. *Keywords: Model studies, Walleye, Yellow perch.*

<u>JAFFE, M.S.</u>, University of Illinois at Chicago, UPP, 412 S. Peoria St. (MC 348), Chicago, IL, 60607.
The Illinois Green Infrastructure Study.

The 2009 Illinois Green Infrastructure for Clean Water Act (P.A. 96-0026) mandates a study on the efficacy, costs and benefits, and implementation of Green Infrastructure to manage urban stormwater discharges to waterways. The Illinois EPA is to report back to the General Assembly by June 30, 2010 its recommendations concerning the use of best management practices (BMPs) to promote stormwater infiltration and attenuation by natural processes. To assess the efficacy of Green Infrasructure BMPs, faculty at UIC assessed the scientific peer-reviewed literature examining TSS, Total Nitrogen and stormwater discharge flow reduction by natural systems, including infiltration, detention, buffers, rain gardens, permeable paving, constructed wetlands, and green roofs. Simulation models that can estimate water quality impacts and stormwater volume flows were also assessed. Staff at the Chicago Metropolitan Agency for Planning reviewed the use of Green Infrastructure BMPs in northeastern Illinois, while the Center for Neighborhood Technology examined regulatory programs in other states that encourage or require Green Infrastructure BMPs as a component of municipal MS4 programs. This paper summarizes the Study's findings and assesses its use of scientific information to guide urban stormwater management in Illinois. *Keywords: Water quality, Management, Decision making.*

<u>JAKOBI, N.J.</u>[1], TARABORELLI, A.C.[1], YUILLE, M.[1], JOHNSON, T.B.[1], BOWEN, K.L.[2], and BOSCARINO, B.[3], [1]Ontario Ministry of Natural Resources, Glenora Fisheries Station, 41 Hatchery Lane, Picton, ON, K0K 2T0; [2]Fisheries and Oceans Canada, Great Lakes Laboratory

for Fisheries & Aquatic Science, Burlington, ON, L7R 4A6; [3]Cornell Biological Field Station, Department of Natural Resources, Cornell University, Bridgeport, NY, 13030. **Distribution, abundance and production of *Hemimysis anomala* in Lake Ontario.**

Hemimysis anomala, an invasive species from the Ponto-Caspian region in Europe, was first reported in Lake Ontario (Oswego, NY) in the fall of 2006. We assessed the distribution and associated density of *Hemimysis anomala* in the nearshore waters of Lake Ontario at 20 Canadian and 8 U.S. sites using standardized methodology during the spring, summer and fall of 2009. Production rates were estimated from biweekly samples collected between early April to late November at Bronte, ON. Sampling consisted of three to five vertical hauls with a 0.7m, 400 μm plankton net off of pier walls at each study site. Water temperatures were recorded and *Hemimysis* were counted, sexed and measured to calculate abundance by sex and life stage. *Hemimysis* density was highest in the northwest and lowest in the northeast. Adult density was highest in the spring and lowest in the summer while juvenile density was highest in the summer and low in the spring and fall. Adult sex ratio was similar in spring and summer, but females outnumbered males in the fall. Our results provide needed information on vital life history parameters needed to estimate production and ultimately ecological impacts of *Hemimysis* in invaded waterways. *Keywords: Lake Ontario, Hemimysis anomala, Distribution patterns.*

JANTUNEN, L.[1], WRIGGLESWORTH, S.[1], BIDLEMAN, T.[1], SVERKO, E.[2], DOVE, A.[2], and BACKUS, S.[2], [1]Environment Canada, 6248 Eighth Line, Egbert, ON, L0L 1N0; [2]Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Tracing Pathways of HCHs Through Lake Superior.**

Hexachlorocyclohexanes (HCHs) are among the most abundant organochlorines in Lake Superior. Technical HCH (alpha-, beta-, gamma-HCH and other isomers) was deregistered in the U.S. and Canada in the 1970s, but use of lindane (pure gamma-HCH) continued into this decade. HCHs in air and precipitation have declined at IADN monitoring stations since the early 1990s. Concentrations in Lake Superior have also declined, by factors of 8-10 for alpha-HCH and 3-4 for gamma-HCH between 1986-87 and 2005. Loss of HCHs from the lake occur through outflow, sedimentation, degradation and revolatilization. Microbial degradation in lake water depletes (+)alpha-HCH, resulting in nonracemic residues with enantiomer fraction EF = (+)/[(+) + (−)] = 0.431 during summer 2005. This is significantly lower than EF = 0.450 in 1996-97, suggesting increased microbial degradation over time. Water/air fugacity ratios (FR) in 2005 ranged from 2.7-7.1 for alpha-HCH and 3.4-9.2 for gamma--HCH, indicating that both HCHs were undergoing net volatilization. In 1996-97 conditions were close to air-water equilibrium for alpha-HCH (FR = 1.3-1.8) and net deposition for gamma-HCH (FR = 0.5-0.6). EFs of alpha-HCH in water and air allowed estimates to be made of the fraction in the air boundary layer due to volatilization. *Keywords: Pesticides, Gas exchange, Environmental contaminants, Chiral compounds, Lake Superior.*

JANTUNEN, L.M.[1], BRICE, K.A.[2], and SU, K.[2], [1]Environment Canada, 6248 Eighth Line, Egbert, ON, L0L 1N0; [2]Environment Canada, 4905 Dufferin Street, Toronto, ON, M3H 5T4.

53rd Annual Conference on Great Lakes Research
Abstracts

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Pentachloronitrobenzene (PCNB) from the Great Lakes Integrated Atmospheric Deposition Network.

Pentachloronitrobenzene (PCNB), the active ingredient in quintozene, is a fungicide registered for usage in Canada and the U.S.A. It is used as a seed or soil treatment for many crops including cotton, potatoes, tulips and onions, and also for mould control on golf courses. In contrast to other pesticides, quintozene is applied to golf courses in late fall and early spring and not in late spring through summer. It is quite volatile and is expected in ambient air around the Great Lakes. The Integrated Atmospheric Deposition Network investigated PCNB in air at three Canadian sites from January 2004 to March 2008. Samples were taken on the regular IADN schedule of 1 day in 12. The sites were in rural areas, Point Petre is on the north shore of Lake Ontario, Burnt Island is in northwestern Lake Huron and Egbert is an agricultural site not situated on a lake. Egbert had the highest median air concentration of PCNB (32 pg/m^3), followed by Point Petre (14 pg/m^3) and the lowest levels were seen at Burnt Island (6.8 pg/m^3). PCNB also showed seasonality, with the lowest levels in June to October at all three sites. Levels were highly variable during other times of the year, showing spikes with a maximum concentration in November 2006 of 2.9 ng/m^3 at Egbert. *Keywords: Pesticides, IADN, Environmental contaminants.*

JIAO, Y.[1] and REID, K.[1], [1]Virginia Tech University, Blacksburg, VA, 24061, US; [2]Ontario Commercial Fisheries Association, Blenheim, ON, N0P 1A0, Canada. **Incorporating Bayesian Model Selection into Bayesian Decision Making in Fisheries Management.**

Model selection uncertainty can be high if one specific model is selected without comparison to other possible models. In this study, using the Lake Erie walleye (Sander vitreus) fishery as an example, we compared several statistical-catch-at-age models to assess the population dynamics. Models that we used included: a state-space statistical catch-at-age model (SCAG) with constant natural mortality, a SCAG with unknown natural mortality but a prior distribution from a tagging study, a SCAG with time-varied natural mortality following a random walk process, a SCAG with a time-varied catchability coefficient following a random walk process, and a SCAG with both natural mortality and catchability following random walk processes. A Bayesian approach was used to estimate parameters, and performance of the models was compared by goodness-of-fit, the retrospective patterns of the models, and the posterior predictive ability. A multi-model inference approach, using a Bayesian model selection algorithm with probability of being selected renewed each year, is suggested when more than one model is plausible for a fishery. Such an approach provides a coherent mechanism to incorporate model selection uncertainty and the decision made based on such an approach is more consistent over time, avoiding abrupt changes caused by model changes. *Keywords: Risk assessment, Bayesian model selection, Decision making.*

JOHANNSSON, O.[1], BOWEN, K.[1], HOLECK, K.[2], and WALSH, M.[3], [1]Fisheries and Oceans, Canada, 867 Lake Shore Rd;,, Burlington, ON, L8s 2A9; [2]Cornell Biological Field Station, 900 Shackleton Point Rd.,, Bridgeport, NY, 13100; [3]United States Geological Survey, 17 Lake Str.,

Oswego, NY, 13126. *Mysis diluviana* **Population Dynamics with** *Dreissenia, Cercopagis* **and** *Bythotrephes* **Invasion of Lake Ontario.**

Most impacts of invading species are indirect, mediated through alterations in food resources, predator attention, and habitat. None of the above invading species is expected to directly impact *M. diluviana*; however, all are expected to alter its food supply either directly or through impacts on competitors (e.g. *Diporeia*, copepods). A comparison between 1990-1995 (invaders essentially absent in deep waters) and 2002-2007 (invaders present) indicates a 50%-60% decline in density, biomass, and production of *M. diluviana*. Analysis of cohort mortality rates across the 2000s revealed that the population was controlled predominantly by food resources, not predation. In comparison, between 1984 and 1995, production was negatively related to alewife predation. Declines in food resources likely result from invader impacts: lower algal biomass, fewer zooplankton. In addition, near loss of the August cohort correlates with high abundance of *C. pengoi* in mid-summer. Thus control of the population has shifted away from top-down forces which are likely unrelated to invader impacts, while the change in cohort structure and decrease in total biomass are likely due to invader impacts and mediated through bottom-up forces. The *M. diluviana* population is now near the maximum the lake can support. *Keywords: Biological invasions, Lake Ontario, Productivity, Mysis, Ecosystem health.*

JOHENGEN, T.[1], PANGLE, K.[2], LESHKEVICH, G.[3], HAWLEY, N.[3], REICHERT, J.[4], GIULIANO, A.[5], and LUDSIN, S.[2], [1]Ciler, 4840 South State Rd, Ann Arbor, MI, 48108; [2]Ohio State University, Aquatic Ecology Lab, Columbus, OH, 43212; [3]Noaa Great Lakes Lab, 4840 South State Rd, Ann Arbor, MI, 48108; [4]1647 Hart Ct, Crofton, MD, 21114; [5]Maryland Department of Natural Resources, 580 Taylor Ave, B-2, Annapolis, MD, 21401. **Biological and Physical Attributes of the Maumee River Plume in Western Lake Erie.**

Western Lake Erie is a dynamic system, owing to wind-driven circulation and stochastic river inputs. In turn, the chemical and physical attributes of the system can vary extensively, which in turn, is expected to drive spatial and temporal variability in biological production across all trophic levels. To better understand this biophysical coupling in western Lake Erie, we used 1) Moderate-Resolution Imaging Spectroradiometer (MODIS) 250-m x 250-m resolution, true color, near real-time imagery to map and track river plumes that form in western Lake Erie during April through June 2006-2008 and 2) weekly field collections to describe the chemical (e.g., nutrients, suspended solids), physical (e.g., temperature, water clarity), and biological (e.g., chlorophyll, zooplankton, larval fish) characteristics of these plumes *Keywords: Fish populations, Remote sensing, Coastal ecosystems.*

JOHNSON, L.B.[1], HOLLENHORST, T.[2], CIBOROWSKI, J.J.[3], and HOST, G.E.[1], [1]Natural Resources Research Institute, Univiersity of Minnesota - Duluth, Duluth, MN, 55811; [2]Mid-Continent Ecology Division, U.S. Environmental Protection Agency, Duluth, MN, 55804; [3]Depatment of Biological Sciences, University of Windsor, Windsor, ON, N9B 3P4. **Great Lakes Environmental Indicators (GLEI) - An Integrated, Watershed Based, Anthropogenic Stressor Scale Approach for the Great Lakes.**

Watersheds are spatially explicit areas within which terrestrial stressors can be quantified and linked to measures of aquatic ecosystem condition. We ued elevation data to delineate 6,000 high resolution Great Lakes coastal watersheds. The watersheds were ordered along the coastline so that they can be agglomerated into larger basins for specific applications (i.e., stretches of high energy shoreline or embayments). We then summarized US and Canada integrated maps of land cover, population density, road density, agricultural land use and point sources to characterize types of anthropogenic stress existing in the basin for each watershed. Each stressor measure was standardized to a common scale. Three methods were used to combine information from the different stressors to form a composite metric; 1) For each watershed the maximum scaled stressor metric was identified – "Max-Rel"; 2) the scaled stressor metrics were summed – "Sum-Rel" and 3) the stressor metrics were processed using principal component analysis – "PC". Analyzing the spatial distribution of these scores allows "a priori" identification of the most pristine & most disturbed watershed, which then allows stratified selection of field sample sites along various anthropogenic stressor gradients as well as identifying benchmarks for indicator development. *Keywords: Assessments, Watersheds, Great Lakes basin.*

JOHNSON, T.B., Ontario MNR - Glenora Fisheries Station, 41 Hatchery Lane, Picton, ON, K0K 2T0. **Fish response to aquatic ecosystem change in the Bay of Quinte, Lake Ontario.**

The Bay of Quinte (Lake Ontario) has undergone dramatic change in the past 3 decades following phosphorous abatement, establishment of numerous aquatic invasive species including dreissenid mussels and round gobies, and associated effects on aquatic habitat and fish community composition. Bioenergetic models were combined with extensive fishery monitoring data from the Bay of Quinte to analyse numerical and growth response of key fish species (walleye *Sander vitreus*, yellow perch *Perca flavescens*, smallmouth bass *Micropterus dolomieui*, white perch *Morone americana*, bluegill sunfish *Lepomis macrochirus*, alewife *Alosa pseudoharengus*, and round goby *Apollonia melanostomus*) to changes in the quantity and / or quality of prey and thermal habitat. By looking across thermal and trophic guilds of fishes, I expect to interpret results more broadly in terms of possible future states of the fish and fish community resulting from ongoing and predicted changes in temperature, productivity, and establishment of additional invasive species. *Keywords: Bay of Quinte, Bioenergetics, Fish.*

JOHNSTON, D.P., PITTS, L., CARTER, M., and MCGAULEY, E., Otonabee Region Conservation Authority, 250 Milroy Drive, Peterborough, ON, K9H 7M9. **Linking Ecology and Hydraulics in Urban Watersheds – Riverview Creek Naturalization Case Study.**

As urban development continues to intensify in the Great Lakes basin, the stresses placed upon urban watercourses increases. Anthropogenic changes adjacent to these watercourses including increased impervious surfaces, increased rainfall runoff and temperature have the ability to alter the natural hydrologic and hydraulic characteristics of the river or stream. Increased flows typically lead to higher velocities and degradation of water quality within these systems. These factors create conditions, which are beyond the natural erosion and temperature thresholds of the system, leading to scour and erosion of the natural substrate and vegetal materials. Erosion of the substrate materials within the watercourse typically results in highly

turbid waters, lower oxygen levels and destruction of vegetal materials and cohesive root-zones. These changes can have a significant impact on the natural ecosystem of the watercourse. Typically these impacts result in tributaries with a reduced ability to sustain benthic macro-invertebrate, fish and vegetation communities. The Riverview Creek Naturalization Case Study will be used to illustrate the design considerations and methods incorporated into a project completed in 2009 in Peterborough, Ontario. *Keywords: Naturalization, Ecosystem health, Riparian, Hydrogeomorphology, Biodiversity, Bioengineering.*

JONAS, J.L., Michigan Department of Natural Resources, 96 Grant Street, Charlevoix, MI, 49729, USA. **Methods for adopting and evaluating lake trout size regulations in Lake Michigan.**

Size limits provide some of the few options that fisheries managers have to meet defined fishery management objectives. In 2005 a series of public workshops were held to evaluate size regulation strategies for two regions of northern Lake Michigan (Grand Traverse Bay, and the area from Frankfurt to Leland). Management goals were: 1) to meet fish population objectives (mortality, protection of spawning stocks), 2) stay below the allowable weight based harvest limits, and 3) maximize harvest within these constraints to address socio-political concerns. Data from lake trout population models were used to predict the likelyhood of meeting the stated management objectives under different size limit scenarios. In 2006, a harvestable slot limit was implemented in Grand Traverse Bay (20-24" and 1 fish >34"), and a maximum size limit adopted in the area from Leland to Frankurt (23" max. and 1 fish >34"). We summarize the results after three years of regulation and compare to predicted output from model simulations, and expected verses observed changes in lake trout population structure and harvest. *Keywords: Lake Michigan, Regulations, Fisheries.*

JUHASZ, M. and CUMMINGS, F.H., School of Environmental Design and Rural Development, Guelph, ON, N1G 2W1, Canada. **Evaluation of agri-environmental program performance: Lessons learned from the EFP and Two Ontario Watersheds.**

This presentation aims to provide an overview of primary research conducted by the presenters through semi-structured interviews, focus groups and a survey between the spring of 2009 and the spring of 2010 with hundreds of dairy farmers in both the Grand River and South Nation watersheds in Southwestern and Eastern Ontario. The goal will be to share findings from an evaluation of three specific agri-environmental programs; the Ontario Environmental Farm Plan, the Grand River Rural Water Quality Program and the South Nation Clean Water Program. Our objectives have been to gain deeper awareness of the factors leading to farmer participation in these programs. With dairy farming sharing a significant portion of active land use in these watersheds, our aim has been to see the effectiveness of programs in improving water quality and overall ecosystem health through continual improvement. This presentation will review dairy farmers' (qualitative and quantitative) responses to and perceptions of program development, the capacity of existing management methods and the potential for new approaches to farmer collaboration, program design and adaptiveness. *Keywords: Policy making, Adaptiveness, Ecosystem health, Public Policy, Decision making, Ecological Restoration Incentives.*

KANDEL, H. and GOMEZDELCAMPO, E., Bowling Green State University, Department of Geology, Bowling Green, OH, 43403-0211.
Spatial Variability of Sediment Delivery in the Sandusky Watershed, Ohio.

The Sandusky Watershed is part of the Great Lakes Basin, and contributes a large sediment load to Lake Erie. Eight Ohio counties drain into Lake Erie via the Sandusky River. Most of the research carried out in the Sandusky River watershed has been on water quality or the effects of dam removal. A few studies have focused on the hydrologic and sediment characteristics of the watershed, but their spatial variability has not been investigated. SEDMOD was applied by subwatershed to determine the high and low sediment delivery zones in the whole watershed. Typically, the till portion of the watershed has higher sediment yield than their non-till counterparts. Since the Sandusky River Watershed is equally divided into southern and central till plain, and northern lake plain, that would indicate that the higher sediment producing zones are in the southern and central part of the watershed. However, some researchers have found that a shift in the proportion of coarse grained to fine grained sediment loading in parts of the Sandusky Watershed could be due to a change in agricultural crops. Information on the spatial distribution of sediment delivery may help watershed managers determine the best management practices to protect the Sandusky River and ultimately Lake Erie. *Keywords: GIS, Watersheds, Sediment load.*

KANE, D.D.[1], CONROY, J.D.[2], CHAFFIN, J.D.[3], WAMBO, K.[4], GRUDEN, C.L.[4], and BRIDGEMAN, T.B.[3], [1]Natural Sciences and Mathematics Division, Defiance College, Defiance, OH, 43512; [2]Aquatic Ecology Laboratory, Department of Evolution, Ecology, and Organismal Biology, The Ohio State University, Columbus, OH, 43212; [3]Department of Environmental Sciences and Lake Erie Center, University of Toledo, Oregon, OH, 43616; [4]Department of Civil Engineering, University of Toledo, Toledo, OH, 43606.
The LEAST We Can Do Is Study HABS: Tracking of Harmful Algal Blooms in the Maumee River.

Harmful Algal Blooms (HABs) composed of the cyanobacterium Microcystis have consistently occurred in the western basin of Lake Erie during the last decade. To determine the source of nutrients and algae that initiates these blooms in the Maumee River-Maumee Bay-Western Lake Erie coupled ecosystems we sampled five sites in the Maumee River (MR), two in Maumee Bay (MB), and four in Western Lake Erie (WLE) during summer of 2009. During three sampling periods (early June, early August, early September), we quantified numerous water quality parameters including Secchi depth (SD) soluble reactive phosphorus (SRP), chlorophyll a (chla) concentrations, and phytoplankton community composition. Sites upstream on MR contained varying amounts of *Microcystis*, which was unknown before the current study. We found that mean SD was typically shallow in MR and mean SRP was greatest in MR, when compared to MB and WLE stations. Finally, mean chla varied temporally with MR having high concentrations in August and September but MB having greatest concentrations in June. These results suggest that high MR nutrient levels support algal biomass (including *Microcystis*)not only in the river and MB but may also provide a source of algae to the western basin of Lake Erie. *Keywords: Nutrients, Microcystis, Lake Erie.*

KANE, D.D.[1], TABIT, M.M.[1], DALKE, D.E.[1], BURDEN, S.R.[1], CARLISLE, K.M.[1], CREIGHTON, J.L.[1], GORDON, B.K.[1], ZIMMERMAN, A.A.[2], MOREAU, R.J.[2], GREENE, M.C.[2], STOUDER, F.M.[2], RENO, H.H.[2], MAYGARDEN, D.F.[3], EGGER, H.L.[3], and SCHIEBLE, C.S.[3], [1]McMaster School for Advancing Humanity, Defiance College, Defiance, OH, 43512; [2]Turtle Cove Environmental Research Station, Southeastern Louisiana University, Hammond, LA, 70402; [3]Pontchartrain Institute for Environmental Studies, University of New Orleans, New Orleans, LA, 70148. **Collegiate Service Learning Using Large Lake Restoration.**

Science as a component of service learning has recently been brought to the forefront by programs such as SENCER (Science Education for New Civic Engagements and Responsibilities). For the past three years, the McMaster School for Advancing Humanity at Defiance College has sent students and faculty to Louisiana to assist with ecological restoration in the Lake Pontchartrain ecosystem. Projects have varied from bald cypress (*Taxodium distichum*) planting, wetland surveys, and salinity studies to the production of environmental brochures and documentaries. These projects were undertaken with community partners in Louisiana and demonstrate that large lake restoration can be a component of service learning programs at the collegiate level. *Keywords: Education, Lake Pontchartrain, Restoration.*

KANE, D.D.[1], CONROY, J.D.[2], BADE, D.L.[3], EDWARDS, W.J.[4], and CULVER, D.A.[5], [1]Division of Natural Science and Mathematics Division, Defiance College, Defiance, OH, 43512; [2]Aquatic Ecology Laboratory, Department of Evolution, Ecology, and Organismal Biology, The Ohio State University, Columbus, OH, 43212; [3]Department of Biological Sciences, Kent State University, Kent, OH, 44242; [4]Department of Biology, Niagara University, Lewiston, NY, 14109; [5]Limnology Laboratory, Department of Evolution, Ecology, and Organismal Biology, The Ohio State University, Columbus, OH, 43212. **The problem starts earlier and farther upstream than expected: *Microcystis* upstream in Lake Erie tributaries early in the year.**

To connect phosphorus load, transport, and use in the western Lake Erie basin, we sampled sites (stream, river, bay, and lake) in both the Maumee and Sandusky ecosystems monthly during spring, summer, and fall 2009. We found high water-column chlorophyll concentrations throughout these coupled systems, even in low-order stream adjacent to agricultural fields. Additionally, chlorophyll concentrations were strongly related to nutrient concentrations, indicating that nutrient concentrations greatly affect phytoplankton abundance. We also found *Microcystis* in these low-order streams early in the season, contrary to expectations. Consequently, decreasing phosphorus loads to remediate Harmful Algal Blooms (HABs) may need to begin with managing runoff from agriculture early in the year. Further sampling and integration of the above observations with physical transport models, productivity measurements, and possibly genetic analyses should assist in informing management strategies to control HABs in western Lake Erie. *Keywords: Phosphorus, Lake Erie, Microcystis.*

KAPUSCINSKI, K.L. and FARRELL, J.M., State University of New York, College of Environmental Science and Forestry, 1 Forestry Drive, Syracuse, NY, 13210. **Description and Comparison of Fish Assemblages at Muskellunge Nursery Sites in the Buffalo Harbor (Lake Erie), Upper Niagara River, and St. Lawrence River.**

Successful management of piscivorous fishes requires understanding the prey assemblages they rely upon, especially during the critical first growing season. However, relations between piscivores and supporting fish assemblages in littoral zones of the Great Lakes have been little studied relative to the pelagic. For example, incomplete knowledge of assemblages at muskellunge nursery sites makes it difficult to manage for favorable nursery conditions. Therefore, we sought to (1) describe fish assemblages at muskellunge nursery sites in the Buffalo Harbor, upper Niagara River, and St. Lawrence River, and (2) compare assemblages among sites and water bodies. Assemblage indices that quantified species richness, diversity, evenness, and dominance were used to describe nursery sites and compare site averages among water bodies. The percent similarity of species among sites was used in a cluster analysis and a nonmetric multidimensional scaling model to visualize and compare relations of assemblages among sites. Principal component analysis of species densities was used to quantify variation among sites and provide insight as to the sources of variation among sites and water bodies. Results were used to determine if assemblage structure at nursery sites was related to habitat differences and year class production of muskellunge. *Keywords: Assemblages, Niagara River, Muskellunge, Fish populations, St. Lawrence River.*

KARATAYEV, A.Y.[1], BURLAKOVA, L.E.[1], MASTITSKY, S.E.[1], PADILLA, D.K.[2], and HAJDUK, M.[1], [1]Great Lakes Center, Buffalo State College, 1300 Elmwood Avenue, Buffalo, NY, 14222; [2]Department of Ecology and Evolution, Stony Brook University, Stony Brook, NY, 11794-5245. **Contrasting Survival And Growth Of Zebra Mussels And Quagga Mussels Under Different Temperature Regimes.**

The exotic zebra mussel (Dreissena polymorpha) and its congener the quagga mussel (Dreissena rostriformis bugensis) have very different invasion histories, with zebra mussels attaining substantially faster rates of spread at virtually all spatial scales. However, in waterbodies where they co-occur, D. r. bugensis often displaces D. polymorpha. To determine if the mechanisms for this displacement are associated with temperature dependent survival and growth, we kept mussels in flow-through tanks with two temperature regimes that are similar to the natural surface-water and hypolimnion conditions of Lake Erie. For each of these temperature regimes we used 3 replicate tanks with only zebra mussels present, 3 replicates with only quagga mussels (150 individuals in each tank), and 3 replicates with both species (75 of each species in each tank). Both species had significantly higher survival at lower temperatures, but zebra mussels had consistently higher mortality than quagga mussels across all treatments. Quagga mussels had significantly higher growth rates than zebra mussels, and both species grew faster at higher temperatures. All results were consistent among replicates, and survival and growth rates did not depend on whether mussels were kept separately or together, suggesting no direct competition. *Keywords: Invasive species, Quagga mussel, Dreissena, Zebra mussel, Macroinvertebrates, Growth.*

KARATAYEV, V.A.[1], KARATAYEV, A.Y.[2], BURLAKOVA, L.E.[2], and PADILLA, D.K.[3], [1]City Honors School, 186 East North Street, Buffalo, NY, 14204; [2]Great Lakes Center, Buffalo State College, 1300 Elmwood Avenue, Buffalo, NY, 14222; [3]Department of Ecology and Evolution, Stony Brook University, Stony Brook, NY, 11794-5245.
Dominance Within The Lake Does Not Represent Invasion Potential For Dreissenids.

Despite similar dates of initial invasion in the Great Lakes, the two species of Dreissena show different patterns of invasion. *Dreissena polymorpha* has thus far spread across numerous waterbodies of North America, while the spread of *Dreissena rostriformis bugensis* has been much more limited. In the recent years, *Dreissena r. bugensis* has been observed to dominate the lower Great Lakes in terms of biomass and density of dreissenids. Considering the main vectors of the dreissenids' spread throughout the United States from the Great Lakes, this study examined the abundances and sizes of the two species on recreational boats from lakes Erie and Ontario. In glaring contrast to the ratios of the dreissenid species in the Great Lakes, *Dreissena polymorpha* was found to obtain similar or larger sizes and density than *Dreissena bugensis* on examined boats - the main vectors of spread for the two species. Thus, we can determine that, despite the dominance of *D. r. bugensis* among dreissenids in these lakes, the introduction of *D. polymorpha* may be just as likely as that of *D. r. bugensis*. *Keywords: Quagga mussels, Zebra mussels, Spread, Biological invasions, Vectors.*

KARSIOTIS, S., BROWN, J.E., PIERCE, L., and STEPIEN, C.A., Lake Erie Center and Dept. Environmental Sci., University of Toledo, Toledo, OH, 43616.
Salinity Tolerance Experiments of the Round Goby: Implications for euryhaline habitats and ballast water exchange control.

The Eurasian round goby invaded the North American Great Lakes in ~1990 via ballast water introduction from the Black Sea area (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 per treatment at 0 (control), 5, 10, 15, 20, 25, 30, 35, and 40 ppt - with 32 ppt being average oceanic conditions - in immediate immersion versus longer-term acclimation experiments (increasing 5 ppt every 3 days). Immersion experiments yielded 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 4 months. Thus, round gobies readily tolerate and acclimate to estuarine conditions, and are unlikely to be affected by oceanic ballast water exchange. We predict that the round goby will spread to estuaries along North American coasts, where their success will be enhanced by their native mytilid mussel prey. *Keywords: Round goby, Salinity tolerance, Biological invasions, Control efforts, Ballast.*

KEESHIG-TOBIAS, L., Department of Geology, Univ. of Toronto, 22 Russell Street, Toronto, ON, M5S 3B1.
Geomythology and the Great Lakes.

Over the last 85 years, the Great Lakes has been the subject of geological and historical research. Aboriginal peoples have inhabited the Great Lakes watershed since time immemorial and hold significant knowledge, pre-contact information, about the geologic history of the area in myths and legend, a potentially huge untapped source of scientific information. Geomythology, a relatively new discipline, is the study of geological occurrences and events recorded in myth and legend. Indigenous Aboriginal geomyths have given scientists valuable insight into certain geological features and events; such as, the volcanic eruption that created Crater Lake, Oregon, some 7500 years ago. In 1999, the frozen remains of Kwaday Dan Sinchi ("Long Ago Person Found") was discovered in melting glacial ice between the Yukon and Alaska. Carbon dating by verifying that this person had lived during the 1400s, and affirmed the First Nations' oral history about ancestral trade routes over the glaciers. More recently, a possible connection between Anishnabe myth and legend and recent lakebed research in Lake Huron has come to light. This presentation will seek to show that Aboriginal traditional knowledge can interface with western science and contribute to a greater understanding of the Great Lakes. *Keywords: First Nations, Geology, Great lakes, Traditional knowlegde, Aboriginal.*

KELLY, M.D.[1], CAMPBELL, L.M.[1], CUMMING, B.F.[1], KIRK, J.[2], and MUIR, D.[2], [1]Biosciences, 116 Barrie Street, Kingston, ON, K7L 3N6, Canada; [2]Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6, Canada. **Methyl Mercury Regulation within Sediments via Cycling Sulphur.**

The bioaccumulation of mercury in aquatic systems is controlled in part by sulphur speciation and cycling. Sulphur fractionation between anoxic sediments and water partitions alter the rate of formation for methyl mercury and chromium reducible sulphides (CRS). Stabilization of mercury depositions generally reduce biotic concentrations; however, little understanding is available for the sulphur trends influencing biotransformations of inorganic mercury. The strength of control over biotic uptake will be described by the efficiency of conversion to methyl mercury. This study seeks to provided annual approximations for sediment sulphur and mercury corresponding to fish which pre-date contaminant regulations. Sediment collections from several Ontario lakes are expected to reveal gradients of sulphur concentrations as measured by chromium reducible sulphur. Fish collections available through the Royal Ontario Museum will be used to assess temporal differences of this transference rate. Low concentrations of mercury sharing high CRS levels are expected to reduce observed biotic accumulation. The control strength of sulphur is thus expected to vary with CRS and will be demonstrated using the gradient observed within Ontario. *Keywords: Sediment control, Biotransformation, Methylmercury.*

KELLY, N.E.[1], YAN, N.D.[1], YOUNG, J.D.[2], and WINTER, J.[2], [1]York University, Department of Biology, Toronto, ON, M3J 1P3; [2]Ontario Ministry of the Environment, 125 Resources Rd, Toronto, ON, M9P 3V6. **Dynamics of the Invasive Spiny Water Flea, Bythotrephes longimanus, in Lake Simcoe.**

Bythotrephes longimanus is an invasive, predaceous zooplankter that is associated with reductions in crustacean zooplankton diversity and Cladoceran standing stocks. It also competes with small fish for zooplankton prey, which in turn may influence water quality and recruitment of fish stocks. *Bythotrephes* invaded Lake Simcoe in 1993, and given the potential impacts of its invasion, there is a pressing need to evaluate the *Bythotrephes* population in order to manage the Lake Simcoe ecosystem successfully. To further this goal, we examined spatial and temporal trends in *Bythotrephes* abundance, body size, and reproduction, at three spatially separated sites from 1999 – 2007, and used multivariate statistical techniques to identify the biotic and abiotic factors influencing its abundance phenology. *Bythotrephes* exhibited large spatial and temporal variation in abundance, but also a mid-season population crash and concurrent decrease in body size which was consistent across all sites. Both males and resting eggs occurred prior to these population crashes in most years. The inter-annual variation in abundance and seasonal timing of population crashes suggest both physical and biological factors may be significant drivers of *Bythotrephes* distribution within the lake. *Keywords: Lake Simcoe, Zooplankton, Invasive species.*

KENDALL, S.T.[1], BIDDANDA, B.A.[1], RUBERG, S.A.[2], NOLD, S.C.[3], GREEN, R.[4], LUSARDI, W.[4], CASSERLY, T.[4], and NEWMAN, S.[4], [1]GVSU Annis Water Resources Institute, 740 West Shoreline Dr, Muskegon, MI, 49441; [2]Great Lakes Environmental Research lab, 4840 South State Rd, Ann Arbor, MI, 48108; [3]Biology Department, University of Wisconsin-Stout, Menomonie, WI, 54751; [4]Thunder Bay National Marine Sanctuary, 500 West Fletcher St., Alpena, MI, 49707. **Production and Respiration of Microbial Mats in the Groundwater Layer of Submerged Sinkholes in Lake Huron.**

Groundwater from deep within the Silurian-Devonian carbonate rocks is continuously flowing through and along the floor of Lake Huron at several submerged sinkhole sites. A sharp chemocline with the overlying lakewater is easily visible with shimmering and color changes. The unique chemistry of the groundwater (no dissolved oxygen, lower pH and ORP, and higher sulfates and other ions) has given rise to spectacular microbial mats whose type, extent of growth, and metabolic processes is dependent, in part, on available sunlight. The combination of low oxygen and elevated sulfate levels appears to be a significant factor in driving the energy flow in these ecosystems; however, the degree of sunlight penetration is clearly involved. Metabolic studies conducted in situ on microbial mats using benthic metabolic chambers and ex situ experiments using 14C-bicarbonate with benthic cores and overlying water show that shallow sunlit springs are clearly photosynthesis dominated, while production processes in the deeper aphotic sinkhole is chemosynthesis dominated. Preliminary data suggest that purple cyanobacterial mats with underlying sediments from Middle Island sinkhole carryout oxygenic and anoxygenic photosynthesis, chemosynthesis, and sulfate reduction. *Keywords: Metabolism, Biogeochemistry, Lake Huron.*

KENNEDY, J.A. and VALENTA, T.J., Green Bay Metropolitan Sewerage District, P.O. Box 19015, Green Bay, WI, 54307. **GBMSD Long Term Monitoring Program on lower Green Bay and the Fox River: 2010 and Beyond.**

The Green Bay Metropolitan Sewerage District (GBMSD) has conducted voluntary water quality monitoring on the waters of the lower Green Bay and the Fox River since 1986. The program provides high quality data which helps to determine the impact of our discharge on the Fox River and Green Bay. Historically, 18 sites have been sampled during the open water season 12-16 times per year. Surveys collect whole water column physical profile and solar radiation measurements. Water samples are collected for analysis of conventional parameters and nutrients. Organic and inorganic pollutant surveys for water and sediment are conducted on a less frequent basis. All monitoring data is maintained in an Access database at GBMSD. Historically GBMSD has collaborated with other agencies that conduct monitoring or research on the Fox River and Green Bay (eg. the State of the Bay website which is maintained by the University of Wisconsin Sea Grant Institute). In early 2009 the GBMSD Commission authorized an expansion of the monitoring program, including the purchase of a new work boat. The new vessel will have increased monitoring capabilities and extended range. GBMSD will pursue future opportunities for collaboration with other researchers or agencies who plan to conduct field activities within the Lower Fox River/Green Bay ecosystem. *Keywords: Nutrients, Green Bay, Monitoring.*

KENNEDY, S., HODSON, P.V., BROWN, S., and CASSELMAN, J., Bioscience complex, Queen's University, Kingston, On, K7L 3N6.
Are dioxin-like contaminants contributing to the population decline of L. Ontario eels (Anguilla rostrata)?

Recruitment of American eel, *Anguilla rostrata*, to L. Ontario has declined by almost 90% since the 1980s. One hypothesis to explain this crash is embryo mortality due to maternally-derived contaminants, specifically TCDD and dioxin-like chemicals accumulated by eels as they grow and mature in L. Ontario. We tested this hypothesis with bioassays of eel tissue extracts injected into embryos of a surrogate species, the Japanese medaka (*Oryzias latipes*). By injecting eel extracts into medaka, we assessed developmental problems associated with the maternal transfer of dioxin-like toxicants to embryos. On day 11 post fertilization, injected eggs were scored for signs of toxicity including blue sac disease, a hall-mark sign of dioxin-induced toxicity. The ED50 of the extracts, expressed as TCDD equivalents, varied with the degree of chemical contamination, as influenced by location of capture. The most toxic eel extracts came from L. Ontario with an ED50 equivalent to 3.79 pg/mg TCDD. This indicates that eels residing in L. Ontario accumulate sufficiently high concentrations of dioxin-like contaminants that their body tissues are toxic to embryonic medaka and probably to their own offspring as well. These results will influence eel remediation programs and management of chemical contamination in Lake Ontario. *Keywords: Lake Ontario, Dioxin, Environmental contaminants, American eel.*

KHOURY, M., SOWA, S.P., BOWMAN, R., and KENDY, E., 101 E. Grand River Ave., Lansing, MI, 48906.
Principles of Environmental Flows In the Great Lakes Region.

The scientific principles of the Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement (The Compact) are consistent with the fundamental principles of Environmental Flows. However, additional principles of the Compact that emphasize ensuring multiple benefits of water availability, accounting for other factors that alter groundwater and

surface water supplies such as climate change, using coordinated and consistent approaches, and promoting efficiency of water use hold the Great Lakes states and provinces to a higher standard. The multitude of scientific approaches that could be used to implement the Compact in conjunction with data disparities and time constraints under the Compact make it difficult to meet this higher standard. Yet, scientific frameworks exist and efforts to foster collaboration to meet this higher standard are underway that are helping those charged with implementing the Compact adhere to this higher standard. This presentation will cover basic principles of Environmental Flows and the Compact and discuss what these principles mean collectively for developing operational programs under the Compact. *Keywords: Environmental policy, Great Lakes basin, Water distribution.*

KILGOUR, B.W.[1], TRUDEL, L.[2], GHARABAGHI, B.[3], PERERA, N.[3], and JARVIE, S.[4], [1]Kilgour & Associates Ltd., Ottawa, ON, K1H 1B8; [2]Environment Canada, Gatineau, QC, K1A 0H3; [3]University of Guelph, Guelph, ON, N1G 2W1; [4]Toronto and Region Conservation Authority, Downsview, ON, M3N 1S4. **Quantifying Road Salt Impacts in Toronto-Area Streams, and Ecological Benefits of Reducing Salt Loads.**

Environment Canada declared road salt a toxic substance in 2001, implemented the Road Salt Code of Practice in 2004, and will be reporting on the ecological benefits of the Code in 2010. This study supports the understanding of the ecological benefits of implementation of the Code. Field data collected by Toronto and Region Conservation Authority between 2000 and 2008 demonstrated significant associations between chloride concentrations in streams and diversity and composition of fish and benthic communities. Streams with high chloride concentration tended to have lower diversity and more "tolerant" taxa. Changes in benthic community composition since implementation of the Code have been significant but subtle, potentially being masked by other stressors such as high nutrient concentrations. Toxicity data can be further used to quantify potential ecological benefit, assuming all other factors are controlled. Species sensitivity distributions predict a benefit of up to 30% of potential taxa in the region, given observed reductions in chloride loadings. *Keywords: Fish, Tributaries, Benthos, Urban areas, Species composition.*

KING, L.E.[1], DE SOLLA, S.R.[2], and QUINN, J.S.[1], [1]McMaster University, Department of Biology, Hamilton, ON; [2]Environment Canada, Wildlife and Landscape Science Division, Burlington, ON. **DNA mutation rate in Double-crested Cormorants (*Phalacrocorax auritus*) associated with exposure to PAH's on Lakes Ontario and Erie.**

Pollution from steel production is a threat to nearby wildlife and a serious concern near Hamilton, Ontario, home to two integrated steel mills. Research suggests this air pollution causes higher DNA mutation rates in herring gulls and mice, with Polycyclic Aromatic Hydrocarbons (PAH's) as a suspected cause. Cormorants are an excellent species in which to study airborne and dietary exposure as they eat almost entirely fish, simplifying the tracing of the aquatic route of contaminant exposure. We collected blood and regurgitated samples from Double-crested Cormorant (*Phalacrocorax auritus*) families in two colonies adjacent to steel mills in Hamilton Harbour (Lake Ontario) and one colony at our reference site on Mohawk Island (Lake Erie),

Ontario, and will continue similarly next season. DNA from the blood samples is being used to determine the germline mutation rate in each colony using several microsatellite loci. To understand dietary exposure, we will investigate whether adult cormorants are foraging from littoral or pelagic food webs, and whether varying diets can cause differing contaminant uptake. Red blood cells used for analyzing stable isotopes and essential fatty acids, along with regurgitated samples, will help further our understanding of diet composition in order to better answer these crucial questions. *Keywords: Cormorants, Mutation, PAHs, Toxicology, Environmental contaminants, Waterbirds.*

KISH, J.L.[1], REED, A.J.[1], OSTER, R.J.[1], WERNE, J.P.[2], and HICKS, R.E.[1], [1]Department of Biology, University of Minnesota Duluth, Duluth, MN, 55812; [2]Large Lakes Observatory and Department of Chemistry and Biochemistry, University of Minnesota Duluth, Duluth, MN, 55812. **Planktonic Archaeal Communities Related to Nitrogen Cycle Processes Change Seasonally in Lake Superior.**

Molecular information about planktonic microbial communities can aid our understanding of in-lake processes like nitrogen cycling. Archaeal abundance and community structure were examined in Lake Superior during 2007 and 2008. T-RFLP fingerprints of planktonic archaeal communities were compared during stratified and mixed lake conditions. Two discrete clusters of archaeal assemblages were present under stratified conditions but only one cluster was evident during mixed conditions. One stratified cluster was associated with water above the deep chlorophyll maximum, and the other with archaeal assemblages found throughout the deep hypolimnion. The composition of archaeal communities changed in surface waters after the epilimnion formed, but deeper communities remained unchanged in the hypolimnion. Analysis of 16S rDNA clones indicated many non-thermophilic crenarchaea were present and similar to Nitrosopumilus maritimus strain SCM1, a marine crenarchaeal ammonia oxidizer. After stratification, copies of the archaeal 16S rDNA and amoA genes were more abundant below the deep chlorophyll maximum but much less abundant in the epilimnion. The composition of the archaeal community changes seasonally in the surface waters of this lake and some members of these planktonic communities may contribute to nitrification in the water column. *Keywords: Nutrients, Microbiological studies, Lake Superior.*

KIVI, M. and DELORME, P., Health Canada, Pest Management Regulatory Agency, Environmental Assessment Directorate, 2720 Riverside Dr, Ottawa, ON, K2J 2W3, Canada. **Scientific evaluation and decision-making process for pest control products in Canada-Environmental Risk Assessment for pesticides in Canada.**

Health Canada's Pest Management Regulatory Agency (PMRA) is responsible for pesticide regulation at the federal level in Canada under the authority of the Pest Control Products Act (PCPA). The PMRA registers pesticides only if a stringent, science-based evaluation shows they will pose no unacceptable risks to human health or the environment and will have value. Under the PCPA, HC-PMRA evaluates new products, new uses of existing products and undertakes a mandated re-evaluation for products on a 15year cycle to ensure they continue to meet current scientific standards; promotes sustainable pest management; and

promotes and verifies compliance with the Act. The Environmental Assessment Directorate (EAD) evaluates data on environmental toxicology and environmental fate of pesticides, and uses this information to conduct and environmental risk assessment. Steps within the risk assessment framework include exposure assessment, hazard assessment, risk characterization and risk mitigation/risk management to address any environmental concerns that may arise from the intended use of a product. Mitigative measures are specified on the product label and can include a variety of measures depending on the risks identified. EAD maintains contacts with other agencies by providing up-to-date information, science, standards and protocols. *Keywords: Risk Assessment, Pesticides.*

KLEIN, D.[1], DORAN, P.J.[2], MAYNE, G.[3], READ, J.[4], DEROSIER, A.[5], LAPENNA, A.[6], and KRAUS, D.[7], [1]The Nature Conservancy, 1048 University Avenue, Rochester, NY, 14607; [2]101 East Grand River Avenue, Lansing, MI, 48906; [3]Environment Canada, Ontario Region, 867 Lakeshore Road, Burlington, ON, L7R4A6; [4]Michigan Sea Grant, Samuel T. Dana Building, 440 Church St., Suite 4044, Ann Arbor, MI, 48109-1041; [5]Michigan Department of Natural Resources, Wildlife Division, PO Box 30444, Lansing, MI, 48909; [6]Natural Heritage Information Centre, Ontario Ministry of Natural Resources, 41 Hatchery Lane, RR4, Picton, ON, K0K2T0; [7]The Nature Conservancy of Canada, RR#5, 5420 Highway 6 North, Guelph, ON, N1H 6J2. **Developing and Implementing Biodiversity Conservation Strategies for Lakes Ontario and Huron.**

The primary goal of conservation planning efforts is the development of strategies for the protection and restoration of biological diversity and the ecosystem services it supports. The Lake Ontario Biodiversity Conservation Strategy was released in 2009, based on the input from experts in Canada and the U.S., representing over 50 agencies and organizations. A similar strategy for Lake Huron will be released in mid-2010. These lake wide strategies used the Conservation Action Planning process to assess the health and conservation needs of key ecosystem components. These efforts also identified five critical threats imperiling the health of the lake ecosystems: incompatible development, invasive species, dams and barriers, non point source pollution and climate change. The final reports provide recommendations to protect and restore, to the full extent possible, the native biodiversity and critical natural processes of the Lake Ontario and Huron basins. These efforts identified, through analysis of biological data and expert judgment, priority watersheds and coastal reaches of the ecosystem that most urgently require conservation action. This presentation will provide a summary of strategy recommendations and priority areas, and discuss how the strategies can be implemented through both local and international initiatives. *Keywords: Planning, Lake Ontario, Lake Huron, Conservation.*

KLING, H.J.[1], STAINTON, M.[2], MCCULLOUGH, G.[3], FINDLAY, D.L.[2], and WATSON, S.[4], [1]Algal Taxonomy and Ecology Inc, 31 Laval Dr., Winnipeg, MB, R3T2X8, Canada; [2]Fisheries and Oceans Canada, 501 University Crescent, Winnipeg, MB, R3T 2N6, Canada; [3]Department of Geography, University of Manitoba, Winnipeg, MB, Canada; [4]Environment Canada, Canada Centre for Inland Waters, Burlington, ON, Canada. **Eutrophication, Algal Microfossils and Cyanobacteria in Central Canadian Lakes.**

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Short sediment cores from Lake Winnipeg (LWPG) Manitoba, Lake of the Woods (LOW) and L227, Experimental Lakes Area are all located in central Canada. Lead 210 and cesium 137 dated cores from these lakes were analyzed for chemical composition and algal remains including both soft tissue and siliceous microfossils. This presentation focuses on the distribution of soft tissue microfossils such as cyanobacteria remains(akinetes, sheaths and mucilaginous sheaths) chlorophyte remains, and dominant planktonic diatom (siliceous microfossils) in the cores related to climate change, as well as experimental and anthropogenic eutrophication. Changes in assemblage composition of microfossils in the cores indicate an increase in lake trophic levels beginning in the mid 60's in LWPG, mid 70's and 80's in LOW (area dependent) and post 1969 in L227. Significant shifts were found in cyanobacterial akinetes (particularly those of Anabaena and Aphanizomenon). The L227 core microfossil history correlates well with the changes found in the plankton record post 1969 depicting the experimental eutrophication and know changes in the nitrogen and phosphorus loading ratios. This study documents the sensitivity of both small and large water bodies to nutrient loading including natural (climate driven)and cultural or experimental eutrophication. *Keywords: Aphanizomenon, Eutrophication, Cyanobacteria, Sediments, Algae, Anabaena.*

KLUMP, J.V., Great Lakes WATER Institute, University Wisconsin-Milwaukee, Milwaukee, WI, 53204.
The Stoichiometry and Magnitude of Carbon Transport and Cycling in the Green Bay Ecosystem of Lake Michigan.

The areal average for carbon burial for the southern Green Bay as a whole is ~12 g C m^{-2} yr^{-1}, roughly twice the average for large lakes and equivalent to 0.015 Tg per year or 0.25% of the global large lake carbon sink term. The maximum organic carbon burial rate in Green Bay is 80 g C m^{-2} yr^{-1}, the result of > 6 fold focusing of fine grained materials with organic carbon concentrations reaching 10%. A key to the role of large lakes as carbon sinks or sources is the stoichiometry of inputs relative to burial and export. The character and magnitude of inputs is determined by biogeochemical processes within the watershed. The Fox River basin of Green Bay is heavily impounded and these reservoirs affect both the residence time and the stoichiometry of nutrient and carbon loading. *Keywords: Biogeochemistry, Carbon cycle, Green Bay.*

KLUMP, J.V.[1], PADDOCK, R.W.[1], ANDERSON, P.D.[1], RUBERG, S.[2], JOHENGEN, T.[2], and BIDDANDA, B.[3], [1]Great Lakes WATER Institute, University Wisconsin-Milwaukee, Milwaukee, WI, 53204; [2]Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 48108; [3]Annis Water Resources Institute, Grand Valley State University, Muskegon, MI, 49441.
Tracking the Rate of Groundwater Mixing in a Lake Huron Sinkhole Using Rn-222.

As part of an interdisciplinary investigation of the biogeochemical processes active in a series of sublacustrine sinkholes recently discovered in Lake Huron, we have attempted to quantify the rate of groundwater mixing using Rn-222 as a tracer. Rn-222 is a conservative, radioactive noble gas with a half life of 3.8 days. By comparing the observed Rn-222 activity in sinkhole waters collected from a remotely operated vehicle with the activity expected based upon

groundwater and lake water end member concentrations and mixing based on conservative ions (e.g. Cl⁻), an estimate of the time of mixing may be derived. These mixing times may then be applied to non-conservative constituents, like methane or nutrients, to estimate removal, uptake or oxidation rates as these waters mix. *Keywords: Biogeochemistry, Groundwater, Lake Huron, Sinkholes.*

KOPF, V.E. and EVANS, D.O., Ontario Ministry of Natural Resources, 2140 East Bank Drive, Peterborough, ON, K9J 6Y3. **Influence of changing climate and lake thermal regime on spawning time of lake trout, Salvelinus namaycush, in Lake Simcoe, 1976-2003.**

Lake trout spawning time has been delayed by warming atmospheric conditions and related changes in the thermal regime of Lake Simcoe. Standard ten foot trap nets were set at two sites, Blackbird Point and Strawberry Island, from 1976 to 2003. Nets were installed in mid September to early October prior to the onshore movement of lake trout and fished until late November. Nets were lifted on average every 2.8 and 3.8 days and a total of 17,092 and 24,841 lake trout were captured. Catches were classified by sex and maturity and cumulative catch curves were fitted to characterize the spawning runs. Atmospheric temperature data was obtained from weather stations at Angus, Barrie and Midhurst, Ontario. The total run duration averaged 35 and 37 days at Georgina and Strawberry, respectively. The timing and duration of the male component of the runs were similar between sites. Spawning time was delayed by about two weeks from the 1970s to 2000s and was correlated with warmer atmospheric and epilimnetic temperatures, but not hypolimnetic temperatures. This suggests that warmer surface waters are now delaying inshore movement of spawning lake trout. *Keywords: Lake trout, Thermal regime, Lake Simcoe, Climate change.*

KRAMER, J.W. and RICHARDS, R.P., Heidelberg University, 310 E. Market Street, Tiffin, OH, 44883. **Atrazine in Northwest Ohio Rivers: Long-Term Trends.**

The National Center for Water Quality Research at Heidelberg University has monitored atrazine concentrations in the Maumee and Sandusky Rivers since 1983, with a program focused on storm runoff during the post-application season. This program has generated atrazine concentration data from more than 2000 samples for each river. The watersheds of these rivers have about 80% row-crop agricultural land use, corn is a major crop, and atrazine is widely applied in these watersheds. Concentrations in the rivers are usually highest during runoff from the first several storms following application, usually in May and June, and are generally low from about September to the following May. Overall, linear regression analysis of the data shows a slight but significant increase in concentration. However, LOWESS smooths indicate a slight decrease during the past ten years. The increasing trend is due to increased frequency of observations above 15 µg/L, and is probably more related to weather patterns than changes in use. Monthly analysis shows increasing trends in April and May, no change in June, and decreasing trends in other months. *Keywords: Atrazine, Trends, Tributaries, Lake Erie.*

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KRANTZBERG, G.[1] and GANNON, J.[2], [1]ArcelorMittal Dofasco Centre for Engineering & Public Policy, McMaster University, Hamilton, on; [2]Great Lakes Regional Office, IJC, Windsor, ON.
Innovation, Evolution and Applications of the Ecosystem Approach.

Henry Regier marshaled the concepts of ecosystem and integrity into the binational regime in the Great Lakes Basin in the early 1970's. We discuss how they were made explicit under the 1978 Great Lakes Water Quality Agreement. The 1987 Protocol helped to make explicit practical meaning of ecosystem integrity of the Great Lakes Basin in practical terms. The Great Lakes Research Advisory Board of the IJC, which had Dr. Regier's scholarship at its core, saw the ecosystem approach as a "necessary integrative framework" linking many human activities with the non-human parts of the Ecosystem and biosphere. The main conclusion of the GLRA was that the "accent on water quality objectives in the absence of an ecosystem approach was constraining the ability to prevent pollution of the Great Lakes". We discuss the evolution of the approach and its revolutionary contributions to resource management around the globe at a myriad of scales.

KRAUSE, A.E.[1] and FRANK, K.F.[2], [1]University of Toledo, Department of Environmental Sciences, Toledo, OH, 43606; [2]Michigan State University, Department of Fisheries and Wildlife, East Lansing, MI, 48824.
The Importance of Network Properties for Understanding Great Lakes Food Webs: A Case Study of Southeastern Lake Michigan.

Finding holistic measures of ecosystem dynamics is challenging. We present multiple holistic measures from network analysis to evaluate the dynamics of a food web network across time for southeastern Lake Michigan. Our analysis showed that the food web was divided into one subsystem contained predominantly pelagic taxa and another contained benthic taxa. We calculated measures to determine a taxon's position in the system. One measure indicated whether a taxon was central to its subgroup sharing strong feeding interactions with other members of its subgroup. The other measure indicated if a taxon helped to bridge energy exchanges between subsystems. We incorporated uncertainty into the following analyses. We found that central taxa had greater biomass change in the pelagic subsystem whereas the peripheral taxa had greater biomass change in the benthic subsystem. Taxa in the pelagic system also had greater changes in biomass than those in the benthic system. Our previous results suggest that the benthic subsystem had more changes in system properties in the same time period based on system properties. Overall, these results indicate that individual taxon biomass change is not necessarily a good indicator of system property change and a taxon's subsystem and position are relevant to the measures of interest to managers. *Keywords: Management, Ecosystem modeling, Food chains.*

KURT-KARAKUS, P.B.[1], BIDLEMAN, T.F.[2], MUIR, D.C.G.[1], STRUGER, J.[1], SVERKO, E.[1], CAGAMPAN, S.[1], SMALL, J.[1], and JANTUNEN, L.[2], [1]Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [2]Environment Canada, 6248 8th LINE, Egbert, ON, L0L 1N0.
CONCENTRATIONS and STEREOISOMER COMPOSITIONS OF MECOPROP, DICHLORPROP and METOLACHLOR in ONTARIO STREAMS; 2006-2007 vs 2003-2004.

Concentrations and stereoisomer compositions of mecoprop, dichlorprop and metolachlor were determined in Ontario stream samples in 2003-2004 and 2006-2007. Median concentrations of dichlorprop and metolachlor in 2006-2007 were not significantly different from those in 2003-2004, however mecoprop concentrations were higher in 2006-2007 (p =0.03). The median enantiomer fraction (EF) of mecoprop was higher in 2006-2007 (0.599) than in 2003-2004 (0.490) (p<0.001). Samples with higher concentrations showed nearly racemic compositions (EF = 0.5) in 2003-2004, while nonracemic compositions in 2006-2007 reflected the switch in usage from racemic mecoprop to single enantiomer mecoprop-P in Canada after 2004. The stereoisomer fraction of metolachlor, was slightly but significantly lower in 2006-2007 (0.863) than in 2003-2004 (0.880) (p=0.002). Samples with higher concentrations showed SFs similar to that of enantioenriched S-metolachlor (0.880). Residues of all three herbicides in low concentration samples showed an increased proportion of the herbicidally inactive stereoisomers. Stereoselective degradation and/or rearrangement in the watersheds might explain these observations. Results show the value of stereoselective analysis to probe changes in product usage and provide toxicologically relevant data for residues of chiral pesticides. *Keywords: Pesticides, Enantioselective degradation, Watersheds, Great Lakes basin.*

KURT-KARAKUS, P.B.[1], MUIR, D.C.G.[1], TEIXEIRA, C.[1], BIDLEMAN, T.F.[2], and SMALL, J.[1], [1]Environment Canada, AEPRD, 867 LakeShore Road, Burlington, ON, L7R 4A6; [2]Environment Canada, CARE, 6248 8th LINE, Egbert, ON, L0L 1N0. **Current-Use Pesticides in Ontario Remote Lakes and Precipitation Samples.**

Seasonal variation and regional variation of current use pesticides (CUPs) was studied in a 3 year study conducted between 2003 and 2005. A total of 163 large water samples from 10 lakes and 51 precipitation samples were analyzed. The frequency of detection of the 26 CUPs (including 3 degradation products) for all 3 years ranged from 0 to 99% in water and from 0 to 100% in precipitation. High frequency chemicals (>60%) were □-endosulfan, metolachlor, atrazine, chlorpyrifos, desethyl atrazine, endosulfan sulphate, trifluralin and dacthal. In general, median values of compounds of interest were higher in 2005 than in 2003 or 2004 (p<0.05). Concentrations were generally higher in the southern lakes. Two major herbicides, metolachlor and atrazine showed higher concentrations in southern and central Ontario lakes compared to northern lakes which are far from intensively farmed areas. Average stereoisomer fractions of metolachlor, SF = sum of 2 active/(2 active+2 inactive) isomers, in lake water ranged from 0.720 to 0.890 while it ranged between 0.799 and 0.928 in precipitation samples, which was close to SF of product in use, S-metolachlor (0.880). *Keywords: Assessments, Precipitation, Pesticides, Ontario remote lakes, Great Lakes basin, Current-use pesticides.*

KUTOVAYA, O.A., MCKAY, R.M., and BULLERJAHN, G.S., Bowling Green State University, Department of Biological Sciences, Bowling Green, OH, 43403. **Detection and expression of genes involved in organic P utilization by freshwater picocyanobacteria.**

We are examining the genetic potential of picocyanobacteria to recruit different sources of organic phosphorus in both Lake Erie and Lake Superior. The pelagic regions of Lake

Superior and eastern Lake Erie are typically P-limited environments, and picocyanobacteria of the genus *Synechococcus* are the dominant primary producers during the summer. Specifically, we are examining the ability of endemic microbes to assimilate organic phosphates and phosphonates. As a proxy for their utilization of these substrates, we are monitoring the expression of two genes, *phnD* and *phoX*. The *phnD* gene encodes the phosphonate binding protein of the ABC-type phosphonate transporter, whereas the *phoX* gene encodes a calcium-dependent alkaline phosphatase. We have developed PCR primers to detect the presence of both genes in the endemic picocyanobacteria, and RT-PCR is being used to examine the patterns of expression that serve to assess the degree of P-stress experienced in the phytoplankton. *Keywords: Phosphorus, Cyanophyta, Microbiological studies.*

LA ROSE, J.K.L.[1], ROBILLARD, M.[1], MOLES, M.[1], DOLSON, R.[1], and WILLOX, C.C.[2], [1]Ontario Ministry of Natural Resources, Lake Simcoe Fisheries Assessment Unit, 26465 York Rd 18, Sutton West, ON, L0E 1R0; [2]Ontario Ministry of Natural Resources,Southern Science and Information Section, Aquatic Science Unit, 26465 York Rd 18, Sutton West, ON, L0E 1R0.
 Natural Reproduction in the Lake Simcoe Coldwater Fish Community.

Lake Simcoe's coldwater fish community has experienced drastic change over the past four decades. Long term fisheries monitoring programs conducted by the Ontario Ministry of Natural Resources, Lake Simcoe Fisheries Assessment Unit (LSFAU), have documented recruitment failures in lake trout (Salvelinus namaycush), lake whitefish (Coregonus clupeaformis) and lake herring (Coregonus artedi). Following this, striking declines and long periods of low abundance were observed for these species into the early 2000s. Lake Simcoe's populations of lake trout and lake whitefish have been supported through intensive stocking. The abundance of burbot (Lota lota), two native sculpin (Cottus sp.) species and the invasive rainbow smelt (Osmerus mordax) also declined during this period. Monitoring conducted since 2001 has confirmed the presence of young, naturally reproduced lake trout, whitefish, herring, rainbow smelt and sculpins. Monitoring data also confirms the survival of multiple year classes of wild, lake trout to adulthood. We will review the timing and extent of this change in the status of Lake Simcoe's coldwater fish community. *Keywords: Lake Simcoe, Fish populations, Monitoring.*

LABENCKI, T.L. and BOYD, D., Ontario Ministry of the Environment, 125 Resources Road, Toronto, ON, M9P 3V6.
 Tracking down potential sources of PCBs in the Hamilton Harbour Area of Concern (AOC).

In the Hamilton Harbour AOC, the BUI *Restrictions on Fish and Wildlife Consumption* is driven by elevated levels of PCBs in sport fish. An event-based survey conducted during 2007 found that PCB concentrations were higher in the Harbour relative to inflow waters. Follow-up in 2008 included five water quality surveys and two 28-day SPMD deployments at 10 Harbour stations. Total PCB concentrations in water and SPMDs varied over two orders-of-magnitude among Harbour stations, with maximum concentrations of 387 ng/L and 23,000 ng/g triolein, respectively. Strong spatial gradients, patterns in temporal variability and PCB congener signatures suggested that Windermere Arm remains the primary PCB source area for the Harbour, and that further investigation was warranted for the Strathearne Ave Slip. In 2009,

sediment coring in this Slip demonstrated that total PCB concentrations as well as the proportion of less-chlorinated congeners increased towards the south end of the Slip to a maximum of 24,000 ng/g. Interpretation of Harbour-wide PCB dynamics remains complex; however both resuspension processes and ongoing inputs may be contributing to the BUI and will continue to be investigated to determine what remedial actions should be taken for this AOC. *Keywords: Source trackdown, Hamilton Harbour, PCBs.*

LAMBERTINO, A.[1], TURYK, M.[1], ANDERSON, H.[2], FREELS, S.[1], and PERSKY, V.[1], [1]School of Public Health, University of Illinois at Chicago, Chicago, IL, 60612; [2]Bureau of Environmental Health, Wisconsin Division of Public Health, Madison, WI, 53703. **Uterine Leiomyoma in a Cohort of Female Great Lakes Sport Fish Consumers.**

Diet and endocrine disrupting persistent organic pollutants (POPs) have been associated with gynecologic conditions including uterine leiomyomas. Great Lakes fish consumption (GLFC) is a source of exposure to POPs such as p,p'-diphenyldichloroethene (DDE) and polychlorinated biphenyls (PCBs). This study was designed to examine the effects of sport fish consumption (FC), DDE and PCB levels on prevalent leiomyomas and to examine retrospectively the effects FC on incidence of leiomyomas in women participating in the GLFC Study. We hypothesized that associations are modified by age, obesity, and breastfeeding. Effects of FC and POP exposures on leiomyomas were modeled using multiple logistic regression and effects of years of FC were modeled using time-dependent Cox proportional hazards regression. FC was associated with prevalent and incident leiomyoma. In stratified analyses, the association of FC with prevalent and incident leiomyomas was significant in the BMI $\geq$ 30 strata. DDE and sum PCBs were not associated with prevalent leiomyomas. However, sum PCBs and antiestrogenic PCB congeners were related to leiomyomas in women who never breastfed. This study demonstrates an association of FC with both prevalent and incident leiomyomas. Stratified models for fish and PCBs support our hypothesis of effect modification. *Keywords: Fibroids, Fish, Uterine leiomyoma, Great Lakes basin, PCBs, DDE.*

LANDSMAN, S.[1], COOK, K.[1], GOBIN, J.[1], GUTOWSKY, L.[1], NGUYEN, N.[1], BINDER, T.[1], LOWER, N.[2], MCLAUGHLIN, R.L.[2], and COOKE, S.J.[1], [1]Biology Department, Carleton University, Ottawa, ON, K1S 5B6, Canada; [2]Integrative Biology, University of Guelph, Guelph, ON, N1G 2W1, Canada. **A review of fish movement and migration studies in the Laurentian Great Lakes: historical perspectives, management needs, and future research opportunities.**

There are a variety of tools available for studying fish movement and migration that range from "low-tech" mark-recapture tagging to more expensive and "high-tech" electronic tagging (e.g., acoustic and radio telemetry, passive integrated transponders, archival loggers). Resource management agencies in the Great Lakes routinely conduct such studies in order to understand the temporal and spatial distribution of fish to identify critical habitats and to determine the connectivity of the different lakes and their tributaries, as well as mixing of different stocks and species. Indeed, knowledge of the movement and migratory biology of fish is fundamental to understanding their ecology and natural history. Despite a long history of

studying the movement of fish in the Great Lakes, this body of knowledge has never been summarized and critically evaluated to identify common themes and reveal future research opportunities. We conducted a literature review with the goal of summarizing existing studies on the movement and migration of fish in the Laurentian Great Lakes. Where appropriate, we also considered studies in tributaries if they were directly related to connectivity with the Great Lakes themselves. *Keywords: Conservation, Fish management, Fish behavior.*

LANGAN, J.S.[1], SEABROOK, S.[2], and MCCORQUODALE, J.A.[3], [1]Stantec Consulting, 800-171Queens Ave., London, ON, N6A 5J7; [2]HCCL, 248 Bagot St., Kingston, ON, K7K 3B7; [3]University of New Orleans, New Orleans, LA, 70148-0001. **Evolution of Approaches to Delineating Source Protection Vulnerable Areas about Great Lakes Water Treatment Plants Intakes.**

One of the key elements of the Ontario Source Protection process is the delineation of vulnerable areas about the raw water intake. In accordance with the Technical Rules some vulnerable areas are prescribed or taken from available mapping. Others are calculated using water movement vectors and a time factor. The approach to delineating the calculated vulnerable area about the intakes for Great Lakes water plants in Ontario has evolved in an iterative process from basic perusal of available data and "professional judgement" to map an area about the intake to application of sophisticated hydrodynamic models with outputs validated with site-specific water movement data to calculate an area in a quantified manner. This presentation reviews the history of approaches used and technical findings to determine the vulnerable areas for a selection of Great Lakes and connecting channel water plants in Ontario. Benefits, limitations, challenges and lessons learned in the Ontario process will be discussed and similarities and differences to that found in the US Great Lakes states' work will be covered. This presentation will be of interest to utility owners and operators with water plants on the Great Lakes and connecting channels, federal, and provincial regulators and associated source protection committees. *Keywords: Regulations, Hydrodynamics, Drinking water.*

LANGSETH, B.J., JONES, M.L., and IRWIN, B.J., Department of Fisheries and Wildlife, Michigan State University, East Lansing, MI, 48824. **Evaluation of Harvest Policies for the Lake Huron Cold-Water Fish Community in a Changing Food Web.**

Lake trout (*Salvelinus namaycush*), lake whitefish (*Coregonus clupeaformis*) and bloater (*Coregonus hoyi*) have historically been important to Lake Huron's cold-water commercial fisheries. With the near-extirpation of lake trout in the mid 1900's, lake whitefish began to dominate commercial harvests. Efforts to rehabilitate lake trout are ongoing, but are hindered by bycatch in the lake whitefish fishery, setting up potential tradeoffs between continued harvest of lake whitefish and restoration of lake trout. In addition to lake trout-lake whitefish interactions, the food-web in Lake Huron has undergone substantial changes. The influence that these food-web changes will have on the interactions among fished species remains uncertain. An ecosystem model was built using the Ecopath with Ecosim software to describe the effects possible harvest policies will have on the cold-water fish community. This modeling framework accounts for direct interactions through fishing as well as indirect interactions through food-web

dynamics. Results from policies with varying levels of fishing pressure are presented, and the influence of alternative hypotheses about food-web structure and ecosystem productivity are explored. *Keywords: Harvest policies, Ecosystem modeling, Lake Huron.*

LANTRY, B.[1], GUMTOW, C.[1], WALSH, M.[1], BOSCARINO, B.[2], and RUDSTAM, L.[2], [1]USGS Lake Ontario Biological Station, 17 Lake St., Oswego, NY, 13126; [2]Cornell University Biological Field Station, 900 Shackelton Point Road, Bridgeport, NY, 13030. **Consumption of the Recent Great Lakes Invader, Hemimysis anomala, by Fish in the Nearshore Waters of Eastern Lake Ontario.**

The Ponto-Caspian mysid, Hemimysis anomala, was first observed in southeastern Lake Ontario in May 2006 and in the diets of alewives there by summer 2007. During June-September 2009, gillnets were fished in areas of known Hemimysis colonization east of Oswego, NY to determine if fish that consume macroinvertebrates were preying upon this new mysid. Three species consumed Hemimysis: alewife (Alosa pseudoharengus), rock bass (Ambloplites rupestris), and yellow perch (Perca flavescens). Hemimysis were observed from alewife stomachs from all months, from rock bass in August and from yellow perch in August and September. Alewife stomachs contained the most Hemimysis (up to 482 individuals in one stomach), while yellow perch and rock bass stomachs were never observed with more than 2 individuals. The percentage composition of Hemimysis in alewife diets was greatest in August (55.2%), while chironomids were most important in June (65.8%) and Bythrotrephes longimanus was an important component in all months (26.1-93.4%). The predominant prey of both rock bass and yellow perch were round gobies. Although Hemimysis were observed only sparsely in the diet of most nearshore fish, their prevalence in alewife diets indicates that they have the potential to alter Great Lakes' foodwebs. *Keywords: Fish diets, Invasive species, Alewife.*

LAWRENCE, P.L., University of Toledo, Dept of Geography & Planning, Toledo, OH, 43606. **Completion of a Watershed Restoration Plan/Stage II Report for the Maumee Area of Concern.**

Since 2004 the Maumee RAP Advisory Committee has been working towards the completion of a watershed restoration plan for the Maumee Area of Concern that will also serve as its Stage II report. The planning process was lead by a plan development team lead by watershed coordinators from Ohio EPA and the Toledo Metropolitan Area Council of Governments (TMACOG) and a series of watershed teams. The plan consists of a volume of background information on the AOC, including detailed descriptions, mapping, assessment of BUIs, and relevant data on water quality issues and concerns for each of the seven watersheds within the Maumee AOC. Volume II of the report contains a comprehensive list of projects to address BUIs and water quality issues and concerns for each watershed. The plan was submitted to the State of Ohio for review by the area assistance team in 2006 and received partial endorsement as a watershed restoration plan. This presentation will provide highlights of the plan/stage II report and recent progress to complete the remaining aspects of the report, subsequent re-organization of the MRAC into Partners for Clean Streams, the implementation of

projects from the plan and future prospects for delisting efforts within the Maumee AOC. *Keywords: Management, Decision making, Watersheds.*

LEADBEATER, D.A. and ROY, M.B., 300 Town Centre Blvd., Suite 300, Markham, ON, L3R 5Z6. **Drowned River Mouth Restoration on the Great Lakes – Exploring the links between hydrology and biology in past restoration projects and demonstrating their influence on the design of current projects.**

Wetlands around the Great Lakes have been subjected to not only controls to basin hydrology and development pressure, but also changes to the watersheds they subtend as the receiving bodies. Several restoration projects have been implemented over the past 20 years with varying objectives and outcomes that feature this interplay of riverine and lacustrine environments. This presentation will provide an overview of the projects, the role that control of hydrology played in the projects and the outcomes to date. The projects will include Cootes Paradise and Grindstone Creek in Hamilton, Oshawa Second Marsh (Phases I and II), Cranberry Marsh, Carruther's Creek Marsh and projects currently in design at the mouth of the Don River. The objective of the presentation will be demonstrating how lessons learned from past experiences have informed the design of current and future projects from the perspective of aquatic habitat and vegetation and the importance of a comprehensive understanding of the link between hydrology and biology. *Keywords: Lessons, Hydrogeomorphology, Don River Mouth, Wetlands, Coastal wetlands.*

LEE, P.F. and STILES, S.A., Department of Biology, Lakehead University, Thunder Bay, ON, P7B 5E1. **Point and Non-point Sources of Eutrophication on the Thunder Bay Waterfront.**

The cause(s) of elevated N and P levels in the water column along the Thunder Bay waterfront were determined. There were two point sources for these nutrients – a paper mill located on the Kamanistiquia River and the Thunder Bay Water Pollution Control Plant. The main suspected source of non-point nutrients was Canada Geese. In order to separate out the likely origin of the nutrients, samples were collected below and above the paper mill and along the waterfront including the location of water intake for the city of Thunder Bay at Bare Point. The nutrient levels along the waterfront were often higher than near the point source sites indicating that non-point sites were also contributing to the nutrient levels. Coefficients of variation for the N and P parameters showed that the sites on the water front exhibited much higher levels of variation than did the sites near the point sources. Similarly, non-metric multidimensional scaling for the data showed that the scatter for sites along the waterfront was much greater than for the point source sites indicating that non-point eutrophication, caused by Canada Geese, was a major source of eutrophication. The study showed that in spite of major improvements to the Thunder Water Pollution Control Plant, non-point sources of nutrient inputs can still result in eutrophic conditions. *Keywords: Lake Superior, Eutrophication, Nutrients.*

LEISTI, K.E.[1], MILNE, S.[2], and DOKA, S.E.[2], [1]867 Lakeshore Road, Burlington, ON, L7R 4A6; [2]PO Box 237, Keene, ON, K0L 2G0. **Assessment of the Offshore Fish Community in Toronto Harbour Using Hydroacoustics and Bottom Trawling.**

Although many studies have documented the nearshore fish community of Toronto Harbour, little is known about the offshore fishes. In September 2009, a daytime hydroacoustic and concurrent bottom trawling program was undertaken. A total of thirty-eight 750 m long transects were trawled in the Inner and Outer Harbours, Outer Islands, Ashbridges and Humber Bays in water depths of 6, 10 and 15 m. Temperature and oxygen profiles were also recorded at the beginning and end of each transect. From the 36,398 fishes caught in the trawls, 56% were alewife, 23% were round gobies and 12% were rainbow smelt. Eight species were caught including threespine stickleback, emerald shiner, white sucker, spottail shiner and round whitefish. Although sampling effort varied, the results from the hydroacoustics indicate that mean fish density ranged from 45 fish/ha in the nearshore area of Humber Bay to 2375 fish/ha in the Inner Harbour. Estimated fish density is highest in the benthic layer (2 m above the bottom) with the majority of fish occurring in schools. A substantial wind event just prior to the end of the survey caused water temperatures to drop up to 15 C. This appears to have resulted in a major change in offshore fish distribution and abundance. *Keywords: Fish, Hydroacoustics, Offshore, Toronto Harbour.*

LEISTI, K.E.[1], DOKA, S.E.[1], and MINNS, C.K.[2], [1]867 Lakeshore Road, Burlington, ON, L7R 4A6; [2]25 Willcocks Street, Toronto, ON, M5S 3B2. **Submerged Aquatic Vegetation Response to Perturbation in the Bay of Quinte: 1972 - 2007.**

Originally a mesotrophic system, the Bay of Quinte experienced eutrophication during the 1940s which resulted in the decline of the once lush submerged aquatic vegetation (SAV) beds by the mid-1960's. Since 1972, twelve SAV surveys have been conducted along ten index transects; six in the upper bay and two in both the middle and lower bays. During this time, two major perturbations occurred within the bay; the reduction in point source phosphorus loadings (P-control) in 1978 and the 1994 invasion by zebra mussels (ZM). SAV response to these perturbations varied temporally and spatially, with the upper bay eliciting the greatest response. In the upper bay, increases in SAV density were recorded after P-control, but the most substantial change to density and extent occurred after the dressenid invasion where there was a three-fold expansion at some of the SAV beds. Some upper bay beds have continued to expand in the post-ZM period, but mean density has decreased from its zenith in 2000. In the middle and lower bays, there was little SAV response to P-control, however the post-ZM period recorded increases in SAV density and depth of colonization. Both basin morphometry and water clarity appear to play major roles in SAV distribution and abundance within the Bay of Quinte. *Keywords: Bay of Quinte, Submerged plants, Zebra mussels.*

LEKKI, J.D.[1] and LESHKEVICH, G.[2], [1]NASA Glenn Research Center, 21000 Brookpark Road, Cleveland, OH, 44135; [2]NOAA/Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108. **Hyperspectral Airborne Monitoring of Microcystis Blooms in Lake Erie: 2009.**

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The NASA Glenn Research Center (GRC) and NOAA Great Lakes Environmental Research Laboratory (GLERL) are collaborating to utilize an airborne hyperspectral imaging sensor to forecast and monitor Harmful Algal Blooms (HABs) in the western basin of Lake Erie. The HABs are very dynamic events and are a concern for human health, fish, and wildlife because they commonly contain a potentially toxic algae, Microcystis. 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 NASA GRC and the Ohio Aerospace Institute (OAI). The system consists of a pushbroom hyperspectral imager, a point spectrometer, a three axis inclinometer, a GPS receiver and a data acquisition and control computer. Mounted on a NASA aircraft, the system was flown over western Lake Erie in August and September of 2009 while in situ water samples were collected. During this time, 75 sample locations were imaged. This data set is large enough to permit statistical analysis of instrument sensitivity and accuracy for Microcystis concentration measurement. Algorithm development and results from the analysis of this data will be presented. *Keywords: Remote sensing, Harmful algal blooms, Lake Erie.*

LENTERS, J.D., University of Nebraska-Lincoln, School of Natural Resources, Lincoln, NE, 68583. **Seasonal Variations in the Lake Superior Energy Balance: Preliminary Results From an Island-Based Meteorological Station Near Marquette, Michigan.**

Variations in climate exert a strong control on the energy and water balance of lakes. This leads to changes in physical lake parameters such as temperature, ice cover, evaporation, and water levels. These changes, in turn, impact the broader lake ecosystem and issues of lake management. It is important, therefore, to understand how climate variability – from short timescales to decadal and longer timescales – drives the lake energy and water balance. An intensive monitoring station was recently deployed on Granite Island (near Marquette, Michigan) to help contribute to our understanding of some of these issues for Lake Superior. This station provides high frequency measurements of the local energy and water balance through precision radiometers, eddy covariance instrumentation, and a suite of meteorological sensors. We present here some of the preliminary results of this study, with a focus on the short-term and seasonal variations in the local energy balance. In particular, we examine the relative roles of radiative and surface heat fluxes in driving changes in lake temperature. *Keywords: Atmosphere-lake interaction, Climatic data, Lake Superior.*

LEON, L.F.[3], MAILKIN, S.[1], DEPEW, D.[1], SMITH, R.E.[1], HIPSEY, M.[2], YERUBANDI, R.[3], and BOWEN, G.[4], [1]University of Waterloo, Waterloo, ON, N2L3G1; [2]University of Western Australia, Perth, Australia; [3]National Water Research Institute, Burlington, ON, L7R4A6; [4]Toronto Regional Conservation Authority, Toronto, ON. **Water Quality and *Cladophora* Modelling in the Nearshore of Lake Ontario : Variations in Algal Growth and the Role of Local Nutrient Sources.**

A nested three dimensional hydrodynamic and ecological model (ELCOM-CAEDYM) was coupled with a model for the dynamics of the benthic nuisance alga Cladophora to analyze the factors controlling its abundance in the nearshore zone of a large lake (L. Ontario). Lake-wide simulations on a horizontal grid of 2 km provided dynamic boundary conditions for a 100 m horizontal grid model of a nearshore study area. The model captured the main features of temperatures, currents, phytoplankton, nutrients and water transparency and provided the environmental drivers for the Cladophora growth model. The coupled model was used to analyze influences on Cladophora cover and biomass, including effects of watershed discharges, sewer outfalls and thermal plumes, in a complex Great Lakes nearshore area. *Keywords: Hydrodynamic model, Water quality, Cladophora.*

LESHKEVICH, G.[1] and LIU, S.[2], [1]NOAA/Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108; [2]Cooperative Institute for Limnology and Ecosystems Research (CILER), 4840 South State Road, Ann Arbor, MI, 48108. **CoastWatch Great Lakes Program After 20 Years.**

CoastWatch is a nationwide National Oceanic and Atmospheric Administration (NOAA) program formed as the result of a red tide event off the North Carolina coast in 1987. In 1990, the CoastWatch Great Lakes regional node was formed at the Great Lakes Environmental Research Laboratory (GLERL). 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 temperature, ice cover, and surface 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: Observing systems, Satellite technology, Remote sensing.*

LESHT, B.M.[1], BARBIERO, R.P.[2], and WARREN, G.J.[3], [1]CSC and University of Illinois at Chicago, 845 W. Taylor St., Chicago, IL, 60607; [2]CSC and Loyola University Chicago, 1359 W. Elmdale Ave., Chicago, IL, 60660; [3]USEPA Great Lakes National Program Office, 77 W. Jackson Blvd., Chicago, IL, 60604. **Upwelling and primary production in Lake Superior.**

Compared to the southern shore and Keweenaw Peninsula, the northern coast of Lake Superior has been little studied. We used ocean color data from SeaWiFS and water surface temperature measurements from buoys, AVHRR, and MODIS to examine the relationship between upwelling events along the northern shore and chlorophyll-a concentrations throughout the lake. We find that upwellings caused by the predominant west-southwesterly summer winds are followed by high chlorophyll concentrations that originate near the coast and move progressively into the open lake. Contrasts between high chlorophyll concentration regions and

surrounding waters can reach 75-100%. *Keywords: Remote sensing, Phytoplankton, Atmosphere-lake interaction.*

LETCHER, R.J., CHU, S.G., and GAUTHIER, L.T., Wildlife and Landscape Science Directorate, Science and Technology Branch, Environment Canada, National Wildlife Research Centre, Bldg. 33, Carleton University, Ottawa, ON, K1A 0H3. **The Increasing Complexity of Brominated Flame Retardants (BFRs) in Eggs of Great Lakes Herring Gulls: Tetrabromobisphenol-S and Tetrabromobisphenol-A Derivatives and Other New BFRs.**

Tetrabromobisphenol A (TBBP-A) is a high production, brominated flame retardant (BFR), and is used to manufacture derivatives including tetrabromo- bisphenol-A-bis(allyl ether) (TBBP-A-ae) and tetrabromobisphenol-A-bis(2,3-dibromopropyl ether) (TBBP-A-dbpe). There are only rare reports on TBBP-A derivatives in environmental matrices including wildlife. In the present study, we developed a sensitive method for TBBP-A-ae, TBBP-A-dbpe and TBBP-S-dbpe determination in bird eggs. The herring gull (*Larus argentatus*) is a key bio-monitoring species of contaminants in the Great lakes ecosystem. We examined TBBP-A-ae, TBBP-A-dbpe and TBBP-S-dbpe in gull eggs collected in 2008 from breeding colonies in the St. Lawrence River basin in Québec, Canada, and in Lakes Ontario, Michigan and Erie. TBBP-A-ae and TBBP-A-dbpe, and not TBBP-S-dbpe, were quantifiable but were extremely low compared to other identified BFRs. We also report on what appears to be structural isomers of the BFR class known as tris(bromocresyl)phosphates in the eggs of Great Lakes herring gulls. Our results continue to demonstrate the increasing complexity of BFRs in Great Lakes herring gulls, and subsequently in their eggs, from dietary and food web bioaccumulation. Further BFR characterization and monitoring is clearly warranted in this key bio-indicator species. *Keywords: Environmental contaminants, Herring gulls, Great Lakes basin, Brominated flame retardants, Bioindicators, Emerging contaminants.*

LEWIS, M.[1], ANDERSON, T.W.[2], CAMERON, G.[1], KING, J.W.[3], and HEIL JR., C.W.[3], [1]Geological Survey of Canada Atlantic, Natural Resources Canada, Dartmouth, NS, B2Y 4A2; [2]25 Dexter Drive, Ottawa, ON, K2H 5W3; [3]Graduate School of Oceanography, University of Rhode Island, Narragansett, RI, 2882. **The Reduced Lakes Erie and Ontario, a Severe Response to a Past Drier Climate.**

Recent analysis of geological evidence of former water level indicators has revealed a long phase of closed basin conditions in the lower Great Lakes in which water levels were drawn down below their overflow outlets for longer than 5 millennia prior to 6000 years ago by evaporation in the drier-than-present early Holocene climate. Similar lowstands existed in the upper Great Lakes basins but for a shorter period of time (about 500 years) due to the prolonged inflow of glacial meltwater. This new understanding results from at least two new developments in Great Lakes geoscience: 1) removal of the distorting effects of differential glacial rebound so the original elevations of lake-level indicators and outlets could be compared, and 2) abandonment of a long-held paradigm that past lakes always overflowed their outlets. Reconstructions show that the lakes fell up to 17 m (Erie) and 30 to 40 m (Ontario) below their overflow sills. These severe lake responses to the drier early Holocene climate could serve as test

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beds for hydrological models, and as examples to enhance public understanding of the sensitivity of the lakes to climate change. *Keywords: Climate change, Water level fluctuations, Holocene.*

LI, A., YANG, R.Q., and WEI,, H., University of Illinois at Chicago, MC-922, 2121 West Taylor Street, Chicago, IL, 60612, USA. **Sediment Record of Halogenated Flame Retardants in the Great Lakes.**

Brominated or chlorinated organic compounds are highly concerned because of their ubiquitous environmental presence and their persistent, bioaccumulative, and potentially toxic characteristics. This work investigates 19 such compounds, most of which are halogenated flame retardants (XFRs). Sediment cores were collected from 16 locations. Concentrations of the XFRs were measured using GC-MS with electron capture negative ionization (ECNI). The target XFRs includes dechlorane plus (Syn- and anti-DP), decabromodiphenylethane (DBDPE), 2,2',4,4',5,5'-hexabromobiphenyl (BB153), 2,3,4,5,6-pentabromoethylbenzene (PBEB), 1,3,5-Tribromobenzene (TBB), Hexabromobenzene (HBB), 2,3,5,6-tetrabromo-p-Xylene (pTBX), tetrabromo-o- chlorotoluene (TBOCT), 1,2,5,6-tetrabromocyclooctane (TBCO), allyl 2,4,6-tribromophenylether (ATE), hexachlorocyclopentadiene (HCCP), pentabromotoluene (PBT), hexabromobenzene (HBB), pentabromobenzyl bromide (PBBB), pentabromochloro- (PBCCH), 1,2-dibromo-4-(1,2-dibromoethyl)cyclohexane (TBECH), hexachlorocyclopentadienyl-dibromocyclooctane (HCBDCO), Hexabromocyclododecane (HCBD) and 1,2-bis-(2,4,6-tribromophenoxy)ethane (BTBPE). The spatial distribution, chronology trend, total accumulation and input rate of the selected XFRs were examined to retrieve the naturally recorded history of pollution in the sedimen *Keywords: PBTs, Halogenated flame retardants, Pollutants, Chemicals of emerging concerns, Sediments.*

LI, H.[1], METCALFE, T.[1], HELM, P.[2], HOWELL, T.[2], and METCALFE, C.[1], [1]Worsfold Water Quality Centre, Trent University, Peterborough, ON, K9J 7B8; [2]Environmental Monitoring & Reporting Branch, Ontario Ministry of the Environment, Toronto, ON, M9P 3V6. **Assessment of the Distribution of Pharmaceuticals and Personal Care Products in a Dynamic Nearshore Area of Lake Ontario Using Passive Samplers.**

Passive samplers were deployed in Lake Ontario near Pickering and Ajax, Ontario and Port Hope, Ontario in 2008 as part of an intensive water quality monitoring study. Semi-permeable membrane devices (SPMDs) and polar organic chemical integrative samplers (POCIS) were used to examine the area of influence of source inputs and the distribution of pharmaceuticals and personal care products in the dynamic nearshore. Physical forcing of surface water conditions by lake currents, winds, and weather conditions presents challenges for water monitoring to obtain overall exposure conditions, especially for chemical contaminants which have high analytical costs. The passive sampling approach offers a solution, providing time-averaged exposures over the course of usually one month. Pharmaceuticals (analgesics, beta-blockers, cholesterol control, antidepressants and antibiotics) were measured in POCIS samplers and personal care products (synthetic musk fragrances and disinfectants) were measured in SPMDs. Pharmaceutical concentrations ranged from ND to 30 ng/L, depending on the compound, and were greatest near wastewater treatment plant discharges. Similar patterns

were observed for musks, ranging from ND to 18 ng/L. Contaminant distributions are evaluated relative to physical and water chemistry parameters in the sampling area. *Keywords: Passive sampling, Lake Ontario, Pollutants.*

<u>LICKERS, H.</u>, Department of the Environment, Mohawk Council of Akwesasne. **Lessons from the Past - Solutions for the Future. Naturalized Knowledge System: An Old Idea Made New.**

In Canada and the United States, legislation and governments are searching for better ways of understanding and working with communities. The research community has long been accused of insensitivity when carrying out scientific studies. The Governments of Canada and the United States have included Aboriginal Peoples in Legislative and Regulator obligations that value the knowledge of Aboriginal Peoples. Research communities are investigating the links between "Western Science" and the knowledge of community peoples whether they are Aboriginal or non-aboriginal peoples. An over reaching idea that will be helpful to governments, academia and native people is the concept of Naturalized Knowledge Systems. This concept recognizes the place and knowledge of not only native people but people who have lived. This session will explore basic assumptions, concepts and patterns of partnerships based on actual cases and experiences. This will provide new insights and will raise awareness of aboriginal perspectives to as part of the implementation of the Great Lakes St. Lawrence River Basin Sustainable Water Resources Agreement. The Mohawk Council of Akwesasne, Department of the Environment has used these principles that are derived from the Great Law of Haudenosaunee in its dealing with governments and academia. *Keywords: Watersheds, Traditional knowledge, Aboriginal, Water level.*

<u>LIN, Z.H.</u>[1], DILLON, P.J.[1], and MOLOT, L.A.[2], [1]Trent University, 1600 West Bank Dr., Peterborough, ON, K9J 7B8; [2]York University, 4700 Keele Street, Toronto, ON, M3J 1P3. **Hypolimnetic End-of-Summer Oxygen Profile Models for Stratified Lakes.**

We tested three previously published multivariate regression models that predict end-of-summer oxygen concentrations in the hypolimnia of lakes- using long-term data collected on 6 small, dilute lakes in Boreal ecozone of Ontario. The first model (Molot et al., 1992) includes only lake morphometry and total phosphorus concentration. The second and the third models relate hypolimnetic oxygen concentration at the end of summer to the difference between the oxygen concentration at spring turnover and the depletion rate of oxygen throughout the entire summer. Livingstone's model (1996) is based on the depletion of oxygen concentration as the sum of an areal oxygen sink (sediment oxygen consumption) and a volume sink (water column oxygen consumption) with hypolimnetic depth. Chapra (1981) derived an empirical equation based on hypolimnetic depth and phosphorus concentration at spring turnover to describe the depletion of oxygen. Our results showed that all 3 models performed better in the deeper lakes than the shallower ones. Reasons why results were poorer when models were applied to shallow lakes are discussed. Based on these analyses, a new multivariate regression model has been developed using a combination of parameters that were utilized in the 3 existing models. *Keywords: Oxygen, Lake model, Water quality.*

LIU, W. and LAMB, K.G., University of Waterloo, Waterloo, ON, N2L 3G1, Canada. **Internal Kelvin Waves in Lake Erie.**

The Kelvin wave is a traveling wave that requires the support of a lateral boundary, with the amplitude decaying away from the boundary. A series of numerical simulations are performed to investigate Kelvin waves in Lake Erie using the MIT General Circulation Model (MITgcm) which is a 3D, non-hydrostatic numerical model. Kelvin waves are observed propagating along the lake boundary after a partially tilted thermocline in the eastern basin or the central basin is released. Moreover, eddies with diameters of several kilometers are formed near Long Point and Point Pelee when higher resolutions (200 meters or less) are utilized. Results from an investigation of the dependence of these eddies on the position, slope and thickness of the thermocline and on the bathymetry will be presented. *Keywords: Waves, Internal waves, Model testing, Lake Erie.*

LIU, Z.[1], KRAUSE, A.E.[1], DROUILLARD, K.G.[2], RUSH, S.A.[2], and JEZDIC, I.[2], [1]University of Toledo, Department of Environmental Sciences, Toledo, OH, 43615; [2]University of Windsor, Great Lakes Institute for Environmental Research, Windsor, ON, N9B 3P4. **Spatially-Connecting the Food Web to Predict PCB Transfers in the Detroit River.**

A previously developed model of PCB bioaccumulation in the food web of the Detroit River has been updated for fish consumption hazard assessment and for effective solutions to reduce PCB sources. The previous model predicted PCB concentration of an individual fish for a given species based on the PCB inputs of a specific river zone. The model has been enhanced through the integration of spatial PCB inputs and the spatial modification of diet matrix. The spatial diet matrix, which quantifies the diet proportions of predator-prey links within and across river zones, was estimated based on the literature and expert opinion about the migration (drifting) behavior and home ranges of each taxon as well as the environmental characteristics of Detroit River. The model was validated with observed PCB concentration data for 37 PCB congeners in 18 fish taxa within each river zone. A Monte Carlo simulation was used to calculate the probability distribution of the model prediction of PCB concentrations in an individual fish. Implementing spatial integration into PCB uptake of fish improves model predictions when compared to previous predictions, particularly for species of concern where the previous model was underpredicting PCB concentration. *Keywords: PCBs, Bioaccumulation, Detroit River.*

LOCHNER, C.[4], MURRAY, J.[1], ANDERSEN, D.[1], MURPHY, C.[2], ERNST, B.[2], RONDEAU, M.[3], SVERKO, E.[4], STRUGER, J.[4], DONALD, D.[5], CESSNA, A.[5], GLOZIER, N.[5], SEKELA, M.[6], PASTERNAK, J.[6], CAGAMPAN, S.[4], and GLEDHILL, M.[6], [1]Environment Canada, Ottawa, ON; [2]Environment Canada, Dartmouth; [3]Environment Canada, Montreal; [4]Environment Canada, Burlington; [5]Environment Canada, Saskatoon/Regina; [6]Environment Canada, Vancouver. **Current-use Pesticides in Selected Canadian Ambient Waters.**

Due to the limited information on the levels and fate of current-use pesticides (CUPs) in Canadian ambient waters, an ongoing study has been undertaken by Environment Canada to determine the levels, fate and trends of current-use pesticides in selected aquatic environments across Canada. To begin to address this key knowledge gap, a surveillance project on pesticides in selected Canadian aquatic ecosystems was conducted under the first cycle of the Pesticides Science Fund (PSF) (2003-2006). This study found that CUPs and their transformation products are widespread in Canadian surface waters, particularly those in agricultural regions. This presentation outlines the PSF surveillance program and focuses on the second cycle of the study which examined the presence and levels of CUPs in selected wetlands/amphibian habitats and surface waters in selected urban centers of Canada. *Keywords: Monitoring, Water quality, Pesticides.*

LOFGREN, B.M.[1] and RUBERG, A.[2], [1]NOAA/Great Lakes Environmental Research Lab, 4840 S. State Rd., Ann Arbor, MI, 48108-9719; [2]U. Michigan Cooperative Institute for Limnology and Ecosystems Research, 4840 S. State Rd., Ann Arbor, MI, 48108-9719.
Projections of Great Lakes Levels Under Enhanced Greenhouse Gases Using Energy Budget-Based Evapotranspiration.

Previously available projections of the influence of greenhouse gas-induced warming on Great Lakes levels have all made use of one suite of regional hydrologic models. The component that simulates evapotranspiration from land uses air temperature as its primary predictor. This method can lead to increases in latent heat flux that significantly exceed the increases in radiative energy input. This is an unphysical result of an empirical fitting that conflates the influence of the strong but transient variation in heat input associated with the annual cycle with that of the weak but steady increase in energy input associated with enhanced greenhouse gas concentration. Modifications were made to this scheme in order to bring it into better agreement with the energy budget constraints that are implied by the driving climate models. Two alternative formulations are believed to yield an answer closer to the correct one, while another formulation can be regarded as yielding the maximum reduction in runoff and hence lake level. However, all three show less of a reduction in runoff than the previously-used formulation, and can even yield rises in mean lake levels. *Keywords: Water level, Evapotranspiration, Climate change.*

LOOKER, M.[1], WATSON, S.B.[1], MCCULLOUGH, G.[2], KLING, H.[3], and STAINTON, M.[4], [1]Environment Canada, CCIW 867 Lakeshore Rd, Burlington, ON, L7R 4A6, Canada; [2]Centre for Earth Observations Science, University of Manitoba, Winnipeg, MN, R3T 2N6; [3]31 Laval Drive, Winnipeg, MN, R3T 2X8; [4]Dept. Fisheries and Oceans, Freshwater Institute, 501 University Crescent, Winnipeg, MN, R3T 2N6.
Fluorescence measures in phytoplankton assemblages: comparison of instruments and taxa.

The Fluoroprobe is becoming a default instrument for fast, relatively cheap mapping of major phytoplankton groups in large lakes. This paper reports on a comparative study of the precision and reproducibility of Fluoroprobe data between individual instruments. Fluoroprobe data from Lake Winnipeg was compared with chlorophyll fluorescence (HPLC) and

phytoplankton species distributions determined by manual identification. Paired Fluoroprobe data collected from continuously pumped lake water was compared with data from a profiling unit at stations. Multiple regression of the Fluoroprobe data explained 63% of variance in chlorophyll a (n = 244) and 51% of variance in counted biomass (n = 58). It successfully predicted bacillariophyte and cyanophyte biomass (r2 = 0.66 & 68 respectively, n = 58) although the RMSE was 10% & 19% of the range in Lake Winnipeg, for the two taxa respectively. It was a weak predictor of cryptophyte and chlorophyte biomass (r2 = 0.21 & 0.32 respectively, n = 58) both of which rarely comprised more than 20% of the biomass. The error of prediction was reduced by local calibration by microscope counts of in situ samples. Seasonal distributions of the four major groups were well represented by Fluoroprobe data; but at times there were large discrepancies in simultaneous measures taken with the two probes. *Keywords: Biomonitoring, Fluorescence measures, Phytoplankton, Species composition.*

LU, Q.[1], DUCKETT, F.J.L.[1], BALDWIN, R.J.[2], and STAINSBY, E.A.[3], [1]Baird & Associates, 1267 Cornwall Rd, Suite 100, Oakville, ON, L6J 7T5; [2]Lake Simcoe Region Conservation Authority, 120 Bayview Pkwy, Newmarket, ON, L3Y 4X1; [3]Ministry of the Environment, 125 Resources Road, Etobicoke, ON, M9P 3V6. **Modeling Assessment of Inter-lake Flushing Rates in Lake Simcoe.**

This study assessed flushing rates between Cook's Bay and Kempenfelt Bay and the main body of Lake Simcoe. The flushing rates represent the overall water exchange rates and also indicate strength of water mixing between the two bays and the main body of the lake. Weak mixing could cause the ecological processes in the two bays to be significantly different from the main lake. The existing three-dimensional model of Lake Simcoe was adjusted to include three nested grids to improve the spatial resolution in the two bays. The model was run during the ice-free seasons from spring to fall for four representative years. Detailed water level, flow velocity and temperature results were output from the model on an hourly time scale. The flushing rate was calculated using the model results as average annual outflow discharge from a bay divided by the total volume of that bay. The results show that the water bodies in the two bays were strongly mixed with the main body of the lake due to wind. This study provided the necessary information to properly conclude that bay specific nutrient loading targets would not be required due to the strong inter-lake mixing of the two studied bays. As well this information will be of significant benefit in continuing to assess and manage ecology of Lake Simcoe and its linkage to hydrodynamic processes. *Keywords: Nutrient Loading Targets, Model studies, Flushing rates, Lake Simcoe.*

LUDEWIG, B.G. and AUSTIN, J.A., Large Lakes Observatory, University of Minnesota, Duluth, Duluth, MN, 55812, USA. **Numerically produced Nowcasts of Circulation, Surface Heights and Hydrography for the St. Louis River Estuary.**

The St. Louis River estuary, including the Duluth-Superior harbor, is an important provider of economic, recreational, and ecosystem services at the far western end of Lake Superior. Circulation, surface height and hydrographic conditions are determined by the complex interaction of local winds and heat fluxes, upstream and tributary hydrological inputs, and the

combined, omnipresent multimodal harbor and lake seiches arising from local and regional meteorological events. These dynamics are captured in a high resolution 3D hydrodynamic numerical model of the estuary. A variable resolution triangular grid was created using estuarine coastlines traced from satellite imagery, a lower resolution lake coastline, and a consolidated bathymetric data set of both lake and estuary. This was input to FVCOM to create a model with a low resolution representation of the entire lake serving as the boundary for a higher resolution estuarine sub-domain. Preliminary results, when compared with NOAA water level data, demonstrate seiche behavior consistent with typical phenomena observed on the lake. Using hourly updated spatially varying meteorological inputs, nowcast products, including ongoing comparisons to instrument derived observations, are posted to the internet as an ecosystem management tool. *Keywords: Estuaries, Hydrodynamic model, St. Louis River AOC.*

LUMSDEN, J.S.[1], RUSSELL, S.K.[1], YOUNG, K.M.[1], AL-HUSSINEE, L.[1], CONTADOR, E.[1], REID, A.[1], WRIGHT, E.[2], and METHNER, P.[2], [1]Fish Pathology Laboratory, Department of Pathobiology, University of Guelph, Guelph, ON, N1G 2W1, Canada; [2]2Ontario Ministry of Natural Resources, Fish Culture Section, 300 Water St., Peterborough, On, K9J 8M5, Canada.
 Chlamydia-like Organism in Ontario Lake Trout (Salvelinus namaycush).

Chlamydia-like organism has been described in both Arctic charr and Atlantic salmon. It affects Arctic charr to a moderate degree in Ontario. In Lake trout however, it has become perhaps the single biggest impediment to enhancement culture of Lake trout at some OMNR facilities. The bacterial inclusions are small and difficult to discern with H&E stain. What does seem to be reasonably consistent however is the pattern of branchial lesions. There is prominent single-cell necrosis of leukocytes and epithelial cells and thickening and blunting of lamellae. Fish of any size from shortly after swim-up can be affected. Not surprisingly, surface treatments are not effective and a preliminary treatment trial with medicated feed (tribrissen and oxytetracycline) was performed. *Keywords: Treatment, Fish hatcheries, Neochlamydia, Fish diseases, Lake trout, Branchitis.*

LUPI, F., SONG, F., and KAPLOWITZ, M., Michigan State University, East Lansing, MI, 48824-1024.
 Economic Value of Public Access to Great Lakes Beaches.

Great Lakes beaches provide important ecosystem services and recreational opportunities, but they are subject to a variety of environmental stressors including encroaching land uses and contamination resulting in advisories or closure. This paper uses an economic model to estimate demand for, and economic value of, public access to Great Lakes beaches in Michigan. Because beaches are not a market good, the travel cost non-market valuation method is used to estimate a multi-site random utility recreation demand model that accounts for the many substitute beaches available to Michigan residents. The model shows that Michigan residents' choices of which Great Lakes beach to visit are significantly influenced by characteristics such as the cost of accessing the beach (negative effect, $p<0.0001$), the length of the beach (positive effect, $p<0.001$), and the number of beach closure days in the previous year (negative effect, $p<0.002$). The economic value of access to a beach depends on the site's characteristics, but values for trips to particular beaches range from $37 to $58 per trip. Scaling

up the values reveals substantial recreation values for access to Michigan's Great Lakes beaches, with access to Lake Michigan beaches being worth over one billion dollars annually. *Keywords: Economic impact, Water quality, Economic evaluation.*

LUPI, F., KAPLOWITZ, M., and CHEN, S., Michigan State University, East Lansing, MI, 48824-1034. **Public Preferences for Great Lake Governance Options.**

We used trade-off modeling to estimate public preferences for Great Lakes governance. The trade-off approach differs from traditional attitudinal scales because respondents cannot simply indicate that they want everything. In our survey of adult residents of Michigan (N=3,116), respondents were introduced to alternative characteristics of Great Lakes governance options through a series of interactive web-pages. The characteristics included factors such as whether interstate decisions must be made by unanimity, the level of public input required for decisions, agency review requirements, and the default level of environmental protection. After completing the governance information, respondents were presented with alternative governance options that differ in one or more of their characteristics and asked to indicate their preferred option. By varying characteristics of the options across the sample, we were able to statistically estimate preferences as a function of the governance characteristics. The resulting statistical choice model revealed that respondents have significant preferences for local input, state agency review required, and unanimity of governors. Further, governance where proposed diversions were required to "show an absence of environmental harm" was preferred to less stringent standards or no standard at all. *Keywords: Political aspects, Policy making, Diversion.*

LYNCH, M.P. and MENSINGER, A.F., Integrated Bioscience, University of Minnesota-Duluth, 1035 Kirby Drive, Duluth, MN, 55812. **Alongshore dispersal of the invasive round goby (Apollina melanostomus) in the Duluth-Superior Harbor of Lake Superior by individual mark-recapture.**

The round goby, *Apollina melanostomus*, is a small benthic fish introduced to the Laurentian Great Lakes from the Ponto-Caspian Region of Eurasia via transoceanic ships in 1990. Although it has quickly spread throughout the watershed, little information is available on its rate and pattern of dispersal. This mark-recapture study utilized alphanumeric elastomer tags subcutaneously inserted into round gobies (n=773). Fish were captured using 16" minnow traps located every 25 meters along a 550 meter stretch of the Duluth-Superior Harbor shoreline. A total of 871 tagged gobies, representing 278 individuals were recaptured from July to October 2009. Net movement between captures exhibited a leptokurtic distribution centered at the site of original capture. Eighty one percent of the recaptured gobies showed no net movement with a maximum recorded movement of 475 meters. Using a random walk passive diffusion model, the rate at which the population expanded was estimated at 16 m2/day. The diffusion coefficient for males less than 100 mm in total length was nearly three times higher than females and males over 100 mm (TL). Other population parameters were calculated including; growth rate, local population size, density per meter of shoreline, and the effectiveness of VI ALPHA tags. *Keywords: Invasive species, Distribution patterns, Round goby.*

LYNN, D.H.[1], MUNAWAR, M.[2], NIBLOCK, H.[2], and FITZPATRICK, M.[2], [1]Department of Integrative Biology, University of Guelph, Guelph, ON, N1G 2W1; [2]Fisheries and Oceans, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Long Term Assessment Of Ciliated Protozoa In The Bay Of Quinte, 2000-2008.**

The abundance, biomass, size spectra and diversity of the community of ciliated protozoa were determined as part of a long term assessment of the microbial loop in the Bay of Quinte. The Belleville and Conway stations were sampled 96 times, typically 13 times per year, from 2000-2007 at both sites and in 2008 samples were collected only at Belleville. Abundance, biovolume, and diversity of ciliates were determined on QPS-stained preparations. Biovolume was converted to biomass (mg Carbon) after accounting for shrinkage due to staining. Abundance ranged from 1,066-35,822 ml-1 (mean 17,848; CV 60%) and biomass ranged from 10.5-215.6 mgC/m-3 (mean 80; CV 77%) at Belleville. Abundance ranged from 3,191-19,989 ml-1 (mean 9,347; CV 54%) and biomass ranged from 13.7-71.8 mgC/m-3 (mean 41.5; CV 42%) at Conway. These abundance and biomass data are comparable to earlier assessments in Lake Ontario made in the 1990s. The results did not show any obvious trends during the study period at Conway, but both abundance and biomass appeared to increase at Belleville, especially in 2007-2008. The community was dominated by oligotrichs, prostomes, peritrichs, and haptorians. Tintinnids were uncommon. Furthermore at Belleville, the relative abundances of haptorians, Halteria, and scuticociliates increased from 2006-2008. *Keywords: Abundance, Microbiological studies, Ciliated protozoa, Bay of Quinte, Biodiversity, Biomass.*

MACCOUX, M.J.[1], CHAPRA, S.C.[2], and DOLAN, D.M.[3], [1]University of Wisconsin - Green Bay, Environmental Science and Policy Program, Green Bay, WI, 54311; [2]Tufts University, Civil and Environmental Engineering, Medford, MA, 2155; [3]Univerity of Wisconsin-Green Bay, Natural and Applied Sciences, Green Bay, WI, 54321. **Total Phosphorus Loads and Mass Balance Model for Green Bay.**

Green Bay is an elongated freshwater embayment located in northwestern Lake Michigan. Due to its shallow depth, the lower bay is heavily influenced by the Fox River's large nutrient load. The inner bay is classified as hypereutrophic and has a well-defined trophic gradient that is observed moving away from the Fox River towards Lake Michigan, where it is nearly oligotrophic. Degraded water quality has caused the Fox River and Lower Green Bay to be classified as an Area of Concern by the International Joint Commission. Phosphorus reductions have been identified as one of the main priorities in the Remedial Action Plan. Recent total phosphorus and chloride loads for the period of 1994-2008 have been estimated as part of a USEPA-GLNPO research grant. Loads will be presented and examined. The data will be used to develop a mass balance budget model for Green Bay. Segments will be used to capture the gradient along the axis of the bay. Future projections and load reduction scenarios will be examined and incorporated into a suggested total maximum daily load for the Fox River. The effects of such policy on the rest of the bay will also be examined. *Keywords: Mass balance, Phosphorus, Green Bay.*

MACECEK, D. and GRABAS, G.P., Canadian Wildlife Service - Environment Canada, 4905 Dufferin St., Toronto, ON, M3H 5T4. **Refining and Reporting Delisting Criteria in the Bay of Quinte Area of Concern using an Existing Regional Coastal Wetland Monitoring Framework.**

In most Canadian Areas of Concern, fish and wildlife populations and their habitats (i.e. Beneficial Use Impairments 3 and 14) have been listed as impaired. While much work has addressed other Beneficial Use Impairments, there was often a lack of specific data and methodologies for evaluating 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 Area of Concern. This approach addressed the challenges of determining what variables to monitor and at what point a beneficial use should be considered as not impaired. Since 2005, water quality, submerged aquatic vegetation, amphibians, macroinvertebrates, fish, and breeding birds have been evaluated using indices. The results have contributed to delisting criteria for Beneficial Use Impairments 3 and 14. Delisting criteria include showing that populations and habitat are among the best in Lake Ontario. For habitat loss, indices are used to evaluate water quality, submerged aquatic vegetation, and macroinvertebrates. Bay of Quinte coastal wetlands were generally in better condition than other Canadian sites along the Lake Ontario shoreline. *Keywords: Monitoring, Coastal wetlands, Bay of Quinte.*

MACKEY, S.D.[1], MARKHAM, J.L.[2], and MACDOUGALL, T.M.[3], [1]37045 N Ganster Road, Habitat Solutions NA, Beach Park, IL, 60087; [2]178 Point Drive North, NYS Department of Environmental Conservation, Dunkirk, NY, 14048; [3]Box 429, 1 Passmore Avenue, Ontario Ministry of Natural Resources, Port Dover, ON, N0A 1N0. **Effects of Lithophyllic Species on Potential Historic Spawning Substrates in the Eastern Basin of Lake Erie.**

Sidescan sonar, RoxAnn, and underwater video data were collected from multiple survey areas in the Eastern Basin of Lake Erie. Underwater video imagery acquired before the introduction of dressenids into Lake Erie show clean boulder-cobble substrates with deep interstitial spaces; ideal potential spawning substrate for lake trout. Recent underwater video data taken from the same areas shows boulder-cobble substrates heavily encrusted with lithophyllic species (dreissenids and Cladophora) which has significantly reduced interstitial pore space. Also observed are significant accumulations of fine-grained sediment (silt/clay) and pseudofeces within the interstitial spaces. We hypothesize that the presence of encrusting lithophyllic organisms increases substrate roughness and had reduced flow and water circulation through interstitial spaces allowing fine sediments to accumulate. These observations suggest that the physical and biological characteristics of historic spawning sites may be considerably different now than in the past. Fish attempting to use historic spawning sites may not recruit successfully and we hypothesize that new less desirable spawning sites, perhaps in shallow water areas, may now be utilized by species requiring boulder-cobble substrates with deep interstitial spaces. *Keywords: Invasive species, Lake trout, Habitats.*

MACPHERSON, G. and MORO, D., 5 Shoreham Drive, Downsview, ON, M3N1S4. **Duffin's Creek Marsh –Rehabilitation of Corner Marsh using Adaptive Management.**

Corner Marsh is an 18ha lagoon within the Duffin's Creek Coastal Marsh Complex which is located in the Town of Ajax. Like many other coastal marshes; controlled water levels, watershed influences and invasive species have all played a role in the degradation of Duffin's Creek Marsh. The TRCA has documented this degradation including the decline of emergent vegetation within Corner Marsh. In 2005, wetland management efforts, including the construction of a levy, were implemented to address these issues and allow for the manipulation Corner Marsh. The main objective of this levy is to allow for adaptive management controls that isolate the marsh from watershed influences, controls water levels and excludes large carp from entering the marsh. Through this adaptive management we have restored historical emergent vegetation conditions, improved water clarity, emergent vegetation, and increase wildlife utilization of the surrounding area. This paper outlines the success of this wetland restoration project in a large urban river. *Keywords: Coastal wetlands, Control systems, Urban watersheds.*

MACRITCHIE, S.M.[1], GOEL, P.K.[1], KALTENECKER, G.[1], FLEISCHER, F.[2], JAMIESON, A.[3], MILLAR, M.[4], RAMANATHAN, L.[5], WORTE, C.[4], and GRGIC, D.[1], [1]125 Resources Road, Ontario Ministry of the Environment, Toronto, Ontario, M9P 3V6, Canada; [2]RR # 1 Bognor, Consultant, Bognor, Ontario, N081E0, Canada; [3]6484 Wellington Rd. 7, Unit 10, Ontario Ministry of Agriculture, Food and Rural Affairs, Elora, Ontario, N0B 1S0, Canada; [4]120 Bayview Parkway, Box 11, Conservation Ontario, Newmarket, Ontario, L3Y 4W3, Canada; [5]300 Water Street, 5th Floor South Tower, Ontario Ministry of Natural Resources, Peterborough, Ontario, K9J 8M5, Canada. **An Approach for Evaluating Two Water Monitoring Networks for Climate Change Detection and Adaptation in Great Lakes Watersheds in Ontario.**

An approach has been developed and applied for the evaluation of two water monitoring networks for their suitability for climate change detection and adaptation. . The Provincial Water Quality Monitoring Network (PWQMN) and the Provincial Groundwater Monitoring Network (PGMN) are partnership programs between the Ontario Ministry of the Environment, the Conservation Authorities (CAs) and ten participating municipalities. Detection monitoring mainly focuses on those watersheds that are part of Environment Canada's Reference Hydrometric Basin Network (RHBN) where minimal or stable anthropogenic influence allows attribution of trends to climate change. Adaptation monitoring focuses on southern Ontario where it is most needed due to population concentrations and anthropogenic influences.. The two step approach for adaptation assessment consisted of a GIS based sensitivity analysis to identify priority watersheds followed by evaluation of the monitoring networks within those watersheds. The evaluation of networks in the second step was conducted by CA staff with expertise in local water issues. The approach for the sensitivity analysis and preliminary results of the network evaluations are presented. *Keywords: Water quality, Observing systems, Climate change.*

MAGNUSON, J.[1], SHUTER, B.[2], and MINNS, K.[3], [1]Emeritus Professor, Center for Limnology, University of Wisconsin-Madison, Madison, WI, 53706, USA; [2]Department of Ecology and Evolutionary Biology, University of Toronto, Toronto, ON, M5S 3B2, Canada; [3]GLFFAS,

Fisheries & Oceans Canada, Burlington, ON, L7R 4A6, Canada.
Henry Regier – His Science and His Influence on Colleagues.

Henry Regier is a scientist whose contribution and influence are important to fish and fisheries science, to broader perspectives of large-scale transdisciplinary science, and to the many colleagues and friends who have been touched by his thoughts and ideas. He is an outstanding scientist, leader, and mentor. He is also a humanist and a philosophical conscience for us all. Not content to let the facts speak for themselves, he thinks deeply about the meaning of science conducted by himself and others, and the importance of the science to challenges from global climate change, to global fisheries, and to rehabilitation of the Laurentian Great Lakes. We are fortunate to have been influenced by his science, his leadership, his mentoring, and his conscience. This talk reviews the roots and the significance of Henry Regier's contributions to science.

MAITY, S.[1], JANNASH, A.[2], GRIBSKOV, M.[3], ADAMEC, J.[2], WATKINS, J.[4], NALEPA, T.[5], HÖÖK, T.[1], SHULTZ, K.[6], and SEPÚLVEDA, M.[1], [1]195 Marsteller St, Purdue University, FORS, West Lafayette, IN, 47907; [2]Purdue University, Bindley Bioscience Center, West Lafayette, IN, 47907; [3]Purdue University, Department of Biological Science, West Lafayette, IN, 47907; [4]Cornell University, Department of Natural Resources, Ithaca,, NY, 14853-2602; [5]Great Lakes Environmental Research Laboratory, Noaa, Ann Arbor, MI, 48105-2945; [6]State University of New York College of Environmental Science and Forestry, College of Environmental and Forest Biology, Syracuse, NY, 13210.
Exploring the Causes of *Diporeia* Declines using Metabolomics.

Diporeia spp. has been a predominant benthic invertebrate in the Great Lakes until early 1990's when their populations have experienced precipitous declines across the Great Lakes except Lake Superior. Our research focus is to use metabolomics to assess the effects of environmental stressors (i.e., starvation, quality/quantity of diatom diet, and exposure to polychlorinated biphenyls and co-exposure to quagga mussels) on *Diporeia*. Metabolites are being measured using GC×GC/MS-TOF and LC/MS. Preliminary results indicate differential metabolite profiles that are stressor-specific. From initial pathway and clustering analysis, a group of metabolites related to a number of metabolic processes (fatty acid biosynthesis, amino acid metabolism, and sphingolipid metabolism) have been selected for further investigation. Our results suggest an underlying pattern in metabolite profiles as a correlational response to the individual stressor. By comparing these metabolite profiles with those from wild populations, we hope to be able to identify potential factors leading to *Diporeia* decline. *Keywords: Great Lakes basin, Diatoms, Diporeia, PCBs, Metabolism.*

MALKIN, S.Y.[1], DOVE, A.[2], DEPEW, D.[1], SMITH, R.E.H.[1], GUILDFORD, S.J.[1], and HECKY, R.E.[1], [1]Department of Biology, University of Waterloo, Waterloo, ON, N2L 3G1; [2]Water Quality Monitoring and Surveillance, Environment Canada, 867 Lakeshore Rd, Burlington, ON, L7R 4A6.
Long-term trends in patterns of water quality in Lake Ontario: Comparing offshore with coastal zones and implications for *Cladophora* growth.

We will present nutrient concentration data from lake-wide epilimnetic monitoring cruises at coastal and offshore stations in Lake Ontario from 1975-2008 and from two littoral zones sites on the north shore from 2004-2008. We found that coastal waters experience earlier drawdown of soluble P due to earlier productivity. We also found statistically significant differences in soluble and particulate nutrient concentrations between the north and south coasts, which we infer are due to dominant hydrodynamic patterns. The north coast has become increasingly oligotrophic concurrent with offshore waters, while the south coast has experienced no decrease in spring SRP or NH_4. A greater frequency of upwelling events on the north coast causes these waters to reflect integrated interannual water quality, while greater downwelling on the south coast retains catchment water in the coastal zone for longer. Intensive monitoring at two littoral zones on the north shore found nutrient concentrations similar to the south coastal nutrient concentrations. A resurgence in *Cladophora* has been observed at these littoral sites over the past decade. Yet, phosphorus loading from the major tributaries to these sites declined from 1965-2006, implicating other mechanisms in fuelling the *Cladophora* resurgence. *Keywords: Nutrients, Lake Ontario, Cladophora.*

MANNING, N.F.[1], MAYER, C.M.[1], BOSSENBROEK, J.M.[1], and TYSON, J.T.[2], [1]University of Toledo Lake Erie Center, 6200 Bayshore Rd., Oregon, OH, 43616; [2]Ohio Department of Natural Resources, Division of Wildlife, 305 East Shoreline Drive, Sandusky, OH, 44870. **Use of Individual Based Models to Explore the Effects of Turbidity on Early Life History Traits of Yellow Perch (*Perca flavescens*).**

Turbidity is an environmental factor that affects the foraging, growth, and survival of age-0 yellow perch. Western Lake Erie is a turbid system, where recruitment is positively related to Maumee River discharge, a major source of suspended solids and nutrients. Laboratory experiments showed reduced larval feeding rates with increasing phytoplankton turbidity and a significantly lower juvenile feeding rate with phytoplankton and sediment -derived turbidity. Previous modeling exercises suggest that turbidity may be the most important environmental factor in determining length and abundances in August of age-0 yellow perch. We modified published Individual Based Models (IBM) (Letcher et al. 1996, Fulford et al. 2006) in order to explicitly account for turbidity intensity and type. These modifications allow for the examination of the effect of turbidity on growth, predator avoidance, and the timing of the ontogenic shift from pelagic to demersal habitats. We show that turbidity type and intensity alter feeding and predator avoidance at multiple life stages, for example: increased sediment turbidity in the encounter sub-models significantly reduced the mass increase per day/ per juvenile but had very little effect on larvae. Increased sediment and algal turbidity also significantly decreased predator mortality rates in both groups. *Keywords: Turbidity, Individual based model (IBM), Yellow perch.*

MAREK, R.F.[1], THORNE, P.S.[2], NORSTROM, A.K.[1], DEWALL, J.[2], and HORNBUCKLE, K.C.[1], [1]Dept. Civil and Environmental Engineering, IIHR-Hydroscience and Engineering, College of Engineerin, The University of Iowa, Iowa City, IA; [2]Dept. Occupational and Environmental Health, College of Public Health, The University of Iowa, Iowa City, IA. **PCBs**

and Their Hydroxylated Metabolites in Human Serum from Urban and Rural Communities: East Chicago, IN and Columbus Junction, IA.

East Chicago, Indiana is a heavily-industrialized community on the southwestern edge of Lake Michigan. Bisecting the area is the Indiana Harbor and Ship Canal (IHSC), which is known to be contaminated with polychlorinated biphenyls (PCBs) and which flows near to residential areas and schools. In contrast, demographically-similar residents of the rural Columbus Junction, Iowa have no known PCB exposure from current or past industrial sources. Due to the apparent difference in exposures, we hypothesize that PCB and OH-PCB serum concentrations and distributions are different between the two cohorts. Blood from 175 school-aged children and their mothers in East Chicago and Columbus Junction were analyzed for all 209 PCBs and 4 common hydroxylated PCB metabolites (OH-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 the results of this analysis and possible implications of our findings. *Keywords: Urban areas, Lake Michigan, PCBs.*

MARKLEVITZ, S.A.C.[1], FRYER, B.J.[2], and MORBEY, Y.E.[1], [1]University of Western Ontario, Department of Biology, London, ON, Canada; [2]University of Windsor, Great Lakes Institute for Environmental Research, Windsor, ON, Canada.
The use of otolith microchemistry to study the natal origins and movement patterns of Chinook salmon in Lake Huron.

Since the initial introduction of Chinook salmon to Lake Huron in 1968 the establishment of naturalized populations have become apparent. In fact, in 2005 naturally reproduced Chinook salmon constituted an estimated 85-90% of the lake wide fishery. With such a large component of the Lake Huron Chinook salmon fishery originating from wild populations it is important to know in which tributaries these fish originate. Our study used the microchemical signature of the otolith to identify the juvenile environments (natal origin) of Lake Huron Chinook salmon. Fry from 17 Chinook salmon spawning tributaries and 7 hatcheries around the Lake Huron region were collected to create a linear discriminant function (DFA) model. This model had 86% accuracy in correctly identifying natal origins. Adult salmon collected from various locations around Lake Huron were then tested using the DFA model to predict natal origin. The results suggest that the majority of Chinook salmon (>50%) in the Lake Huron fishery originated from southern Georgian Bay tributaries. *Keywords: Salmon, Otolith, Fish tagging, Fish management.*

MARTIN, B., CZESNY, S.J., and REDMAN, R.A., Illinois Natural History Survey, University of Illinois, Lake Michigan Biological Station, 400 17th Street, Zion, IL, 60099, United States.
Vertical distribution of larval fish in pelagic waters of southwestern Lake Michigan.

Due to variability in biotic and abiotic conditions along a vertical gradient within aquatic systems, the vertical distribution of larval fish can profoundly affect their growth and survival. In large systems such as the Great Lakes, vertical distribution patterns can also influence dispersal and ultimately settlement events. Despite its importance during early life stages, little is known about vertical distribution patterns of larval fish in Lake Michigan. Our objective was to determine the vertical distribution and describe diel vertical migration patterns of the larval fish

community in pelagic waters of Lake Michigan. To determine vertical distribution, the upper 27 meters of the water column was divided into seven discrete depth bins. Larval fish sampling was conducted within each of these depth bins on seven occasions during both day and night. Temperature, light intensity, and prey density were also recorded at depths corresponding to larval fish sampling. We collected over 1900 larval fish from 5 species: bloater, alewife, burbot, yellow perch and deepwater sculpin. Temperature had the greatest impact on vertical distribution of the larval fish community. The vertical distribution and diel vertical migration patterns of each species will be discussed along with potential consequences for growth, survival and dispersal. *Keywords: Lake Michigan, Larval fish, Pelagic, Diel movements.*

MARTIN, G.M. and TAYLOR, W.D., Department of Biology, University of Waterloo, Waterloo, ON, N2L 3G1. **Does the Spatial Distribution of SRP Support the Role of Allochthonous Inputs and/or Dreissenids in Fostering *Cladophora* Growth in Lake Ontario?**

Despite the success of phosphorus loading controls in remediating eutrophication problems in the Great Lakes during the 1960's and 1970's, nuisance *Cladophora glomerata* returned to shorelines and water intakes in the 1990's, especially in the lower Great Lakes. In an attempt to quantify the degree to which local inputs and internal cycling by dreissenid mussels contribute to phosphate (PO_4^{3-}) concentrations that permit *Cladophora* growth, intense sampling for soluble reactive phosphorus (SRP) was carried out from May to October, 2009, in a nearshore segment of Lake Ontario near Pickering, Ontario. SRP concentrations ranged from 0.3-6.3 µg/l, with the lowest overall concentrations occurring in August and the highest occurring in October. The results suggest higher SRP in the nearshore compared to offshore waters and there is evidence of elevated SRP concentrations in samples taken near point source and non-point sources, as well as above mussel beds versus surface waters. As the standard SRP assay is known to overestimate (PO_4^{3-}) in P-limited waters, alternative methods such as dialysis combined with MAGIC and a steady-state radiobioassay were also utilized and their results will be compared. *Keywords: Coastal ecosystems, Cladophora, Lake Ontario, Phosphate, Phosphorus, Mussels.*

MARTIN, P.A., DE SOLLA, S.R., MIKODA, P., and PALONEN, K.E., Wildlife and Landscape Directorate, Environment Canada, Burlington, ON, L7R 4A6. **Toxicity and absorption of pesticides and fertilizers to snapping turtle eggs (Chelydra serpentina).**

Many reptiles oviposit in soil, including agricultural landscapes, and have the potential to be exposed to agrochemicals. We evaluated the toxicity of nitrogenous fertilizers and a complex mixture of pesticides simulating corn and potato production in Ontario, to snapping turtle eggs. Eggs were exposed in raised garden beds to simulate realistic exposures, and in the laboratory in covered bins so as to minimize loss of volatile compounds. Compounds were applied at typical field application rates, and up to 10 times these rates. Hatching success, deformities and body size were evaluated. Aqueous ammonia reduced hatching success at 2.3 × field application rate, causing complete mortality at higher exposures. Laboratory exposures resulted in reduced hatching success and lower body mass at the highest concentrations. Field rates of pesticide

mixtures did not affect turtle development at typical application rates. Turtle eggs were also exposed to 22 pesticides in soil to examine absorption. Turtle eggs absorbed pesticides readily, indicating lack of toxicity of pesticides is not due to lack of embryonic exposure. Pesticides absorption was negatively associated with sorption to organic carbon (log KOC) or to lipids (log KOW), and high water solubility *Keywords: Pesticides, Turtles, Nutrients, Toxic substances.*

MARTINEZ, A. and HORNBUCKLE, K.C., 4105 Seamans Center for the Engineering Arts and Sciences, Iowa City, IA, 52242. **Dispersion of PCBs volatilized from a contaminated waterway in Lake Michigan.**

In a previous study we determined that Indiana Harbor and Ship Canal (IHSC), IN, is a source of PCBs to the air above it. The concentration of ΣPCBs over the IHSC ranged from 2,000 to 9,000 ng m-3. We hypothesized that the PCBs emitted from IHSC are continuously dispersed into East Chicago, IN. We addressed this hypothesis using an atmospheric dispersion model. AERMOD was utilized to predict airborne PCB52 concentrations in the surrounding areas of IHSC, including East Chicago, for 2008. Performance of the model was assessed using field measurement data (50 ± 20 pg m-3). Results showed that IHSC emissions generate a plume that covers East Chicago. The predicted PCB52 gas phase concentrations ranged from 92 pg m-3 directly over the IHSC to 0.1 pg m-3 6 km from the water. The PCB air concentrations were then measured over the distance of expected impact using passive samplers that integrated concentrations over 6 weeks. The model underestimated the concentration by about one order of magnitude. The most likely explanations for the underestimation include underestimation of the spatial extent of the surface water emission source or missing sources of PCBs. Despite these results, AERMOD is helpful tool for evaluating local POPs exposure potential for communities surrounding a contaminated waterway. *Keywords: Sediments, PCBs, Atmosphere-lake interaction.*

MARTY, J.[1], BOWEN, K.[2], KOOPS, M.A.[2], POWER, M.[3], and DE LAFONTAINE, Y.[4], [1]St Lawrence River Institute, 2 Belmont Street, Cornwall, ON, K6H 4Z1; [2]Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [3]Univerity of Waterloo, 200 University West, Waterloo, ON, N2L 3G1; [4]Centre St Laurent, Environment Canada, 105 Mc Gill, Montreal, QC, H2Y 2E7. **Hemimysis anomala diet and trophic position: a comparative study between lentic and lotic ecosystems using stable isotopes.**

Although planktonic communities differ greatly between lentic and lotic ecosystems, *Hemimysis anomala* (HA) is now found in 4 of the Great Lakes as well as in several locations in the St. Lawrence River. The goal of this presentation is to summarize the results of a study conducted in 2008 and 2009 to characterize the food web structure and determine the main food sources and trophic position of HA in both Lake Ontario and St Lawrence River invaded nearshore sites. Potential food sources (particulate organic matter, periphyton and several zooplankton taxonomic groups) and predator (fish) samples were analyzed for carbon and nitrogen stable isotope compositions. HA samples were analyzed according to size classes sizes to detect possible ontogenetic changes in diet between young (<5mm) and adult (>5mm) organisms. In Lake Ontario, the high variation in $\delta_{13}C$ signatures among individuals indicates

that HA is able to feed on multiple food sources, including both pelagic and benthic production. Variations in diet had no effect on HA trophic position as inferred from $\delta_{15}N$ signatures. The results from Lake Ontario will be compared to those obtained from the St Lawrence River. This study indicates that HA could potentially increase the connectivity between benthic and pelagic food webs. *Keywords: Invasive species, Food chains, Stable isotopes.*

MARTYNOV, A., SUSHAMA, L., and LAPRISE, R., Centre ESCER, Université du Québec à Montréal, 201, Avenue Président-Kennedy, Montréal, QC, H2X 3Y7.
Interactive Lakes in the Canadian Regional Climate Model (CRCM): Present State and Perspectives.

Interactive lakes are introduced into the Canadian Regional Climate Model (CRCM), aiming at better simulation of regional climate, particularly for lake-rich regions, such as the Canadian Shield and the Laurentian Great Lakes region. During the first phase, two 1D lake models were interactively coupled with CRCM4, the current operational version of the model. Decadal simulations with the coupled model over a domain covering the Great Lakes are presented and compared with simulations that did not take into account lakes or used a simple mixed-layer lake model. The lake coupling for both resolved and sub-grid lakes is currently being realised for the next (fifth) generation of the regional model (CRCM5), which is based on the GEM numerical weather prediction model. Preliminary simulation results are presented and compared with standard CRCM5 and with coupled CRCM4 simulations. *Keywords: Atmosphere-lake interaction, Model studies, Climatology.*

MARVIN, C.H., BURNISTON, D.A., MARTIN, P., BACKUS, S., SMYTHE, S.A., PELLETIER, M., BANIC, C., and NEILSON, M., Environment Canada, Burlington, ON, L7R 4A6.
Occurrence, Distribution and Fate of Polybrominated Diphenylethers in the Canadian Environment.

Environment Canada's Chemicals Management Plan (CMP)Monitoring and Surveillance Program focuses on monitoring of chemicals in multiple environmental media: air, water, sediment, non-human biota (fish and wildlife); as well as source monitoring (e.g., wastewater treatment plant effluents and sludge). This program complements the human health monitoring conducted by Health Canada. Together these programs generate science-based information essential to identifying risks and informing risk assessment and risk management, and to support informed decision-making. As part of a case study, we have recently compiled available information on the occurrence, distribution and fate of polybrominated diphenylethers (PBDEs) in Canada. Assessment of temporal trends show apparent decreases beginning around the year 2000 in sediment and fish while trends in wildlife are more variable and site dependant; there is some evidence for declines in air. PBDE levels nationally are influenced by multiple sources (local and atmospheric deposition). Levels in birds, fish and sediment are influenced by proximity to urban and industrialized centers; levels in air may also impacted by transboundary transportation. Significant progress is being made toward elimination of tetraDBE, pentaBDE and hexaBDE. Management of ongoing diffuse sources of PBDEs sh *Keywords: Ecosystem health, Watersheds, PBDEs.*

MATOS, L.[1], SNODGRASS, W.J.[2], and HAWKINS, S.[3], [1]Environment Canada, 4905 Dufferin Street, Toronto, ON, M3H 5T4; [2]City of Toronto, Metro Hall, 55 John Street, 18th Floor, Toronto, ON, M5V 3C6; [3]Toronto and Region Conservation, 70 Canuck Avenue, Downsview, ON, M3K 2C5. **Review of Projects which may lead to delisting of Toronto & Region as an AOC.**

This paper summarizes the beneficial use impairments of the Toronto and Region Area of Concern (AOC), and reviews the various projects (actual and anticipated) that will provide a scientific basis for delisting the AOC. The Toronto and Region AOC Stage 1 report identified eight Beneficial Use Impairments (BUIs) in this AOC, with an additional three BUIs requiring further assessment (RFA). The BUIs relating to contamination of fish and wildlife have each undergone evaluation and, pending confirmatory results, are anticipated to advance toward delisting. Far more complex in both assessment and remediation are the BUIs affected by the AOC's main challenges: continued urbanization, stressors on fish and wildlife populations and, in particular, degraded water quality resulting from stormwater and combined sewer overflows. It is these projects for which updated implementation approaches, an increase in scientific understanding, and science-based refinement of BUI delisting criteria are required to support delisting efforts. Studies are underway to confirm that another four BUI's can advance to delisting, pending implementation of the Wet Weather Flow Master Plan's projects, and 2 BUI's (loss of habitat; fish and wildlife population) through implementation of waterfront redevelopment initiatives, which include habitat creation. *Keywords: Remediation, Urbanization, Water quality.*

MAYER, A.S.[1], BALLARD, M.M.[1], FITZGERALD, K.A.[1], GYWALI, R.[1], MO, W.[2], WATKINS JR., D.W.[1], and ZHANG, Q.[2], [1]Michigan Technological University, 1400 Townsend Drive., Houghton, MI, 49931; [2]University of South Florida, 4202 E Fowler Avenue, ENC 3300, Tampa, FL, 33620. **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, and water treatment cost and energy models. *Keywords: Watersheds, Model studies, Regional analysis.*

MAYER, D.[1], PÉREZ-FUENTETAJA, A.[2], NISHIKAWA, K.[1], SHI, H.[3], GAIKOWSKI, M.[4], ALOISI, D.[5], HUBERT, T.[4], GAYLO, M.[1], BURLAKOVA, L.[2], KARATAYEV, A.[2], CLAPSADL, M.[2], BRADY, T.[5], LUOMA, J.[5], and MOLLOY, D.[1], [1]New York State Museum, Field Research Laboratory, 51 Fish Hatchery Road, Cambridge, NY, 12828; [2]Great Lakes Center, Buffalo State College, 1300 Elmwood Avenue, Buffalo, NY, 14222; [3]University at Albany, Department of Biological Sciences, Albany, NY, 12222; [4]USGS Upper Midwest Environmental Sciences Center, 2630 Fanta Reed Road, La Crosse, WI, 54603; [5]USFWS Genoa National Fish Hatchery, S5631 State Highway 35, Genoa, WI, 54632. **Potential to Manage the Impacts of Invasive Species on Endangered Wildlife in the Great Lakes.**

Our research team is preparing to launch two invasive species management projects: BOTULISM PATHWAY: The epidemic of botulism E has caused the deaths of thousands of fish and birds. The type E toxin is secreted by the bacterium *Clostridium botulinum* and can cause paralysis and death upon ingestion. However, the benthic food web interactions involved in this outbreak remain unclear. Two invasive species groups are thought to play roles: *Neogobius melanostomus* (round gobies) and *Dreissena* spp. (quagga and zebra mussels), but conclusive proof has yet to be provided as to exactly what role dreissenids play in goby intoxication. Development of an inexpensive assay for detection of ultra low quantities of this toxin in environmental samples is a priority. This breakthrough assay would enable tracking of the toxin's trophic pathway through the benthic invertebrate community to gobies. This could lead to nearshore management practices that could predict and potentially even prevent these outbreaks. UNIONID RESTORATION: Great Lakes basin unionids are imperiled by dreissenid fouling, but no control methods are yet available for use in open waters. Because of its non-target safety demonstrated to date, a newly emerging bacterial biopesticide could well prove valuable in such endangered unionid restoration efforts *Keywords: Invasive species, Botulinum Type E, Dreissena, Unionid restoration, Fish diseases.*

MAZUMDER, A.[1], EVANS, D.[2], GINN, B.[3], MAZUMDER, S.[1], and VERENITCH, S.[1], [1]Water and Aquatic Sciences Research Program, University of Victoria, Victoria, BC, V8W3N5, Canada; [2]Aquatic Research and Development Section, Ontario Ministry of Natural Resources, Trent University, Peterborough, ON, K9J 7B8, Canada; [3]Lake Simcoe Region Conservation Authority, 120 Bayview Parkway, Box 282,, Newmarket, ON, L3Y 4X1, Canada. **Paleo patterns of algal pigments, C/N isotopes and nutrients provide new insights into historic water quality trends in Lake Simcoe.**

During the last 200 years, the Lake Simcoe ecosystem has provided domestic water supply and sewage disposal services, recreational fisheries and agriculture for an expanding human population in southern Ontario. The intense forest harvesting, agriculture, industrial and municipal activities in the Lake Simcoe basin lead to increased loading of nutrients, carbon and sediments, and associated deterioration of water quality indicated by algal blooms, reduced transparency, oxygen depletion, and reduced biomass of several fish species. We wanted to evaluate how landuse and development activities affected concentrations of different algal groups, total algal biomass, loading of anthropogenically-impacted nitrogen and carbon, and to

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test if the different basins of Lake Simcoe showed variable responses to landuse and development. We took three 40-50 cm deep cores from each of the three distant basin locations on the lake, and analyzed pigment types and concentrations to help develop the chronology of algal blooms by major groups and changing biomass. We also analyzed stable isotopes of nitrogen and carbon to determine the changes in the loading of land-based N and C to the lake. We use these results to evaluate linkages among landuse history and historic trends in water quality and to suggest management strategies for Lake Simcoe. *Keywords: Lake Simcoe, Paleolimnology, Eutrophication.*

MCCALLA, S.G.[1], ZANIS, M.J.[2], STOTT, W.L.[3], SEPÚLVEDA, M.S.[4], HÖÖK, T.O.[4], NALEPA, T.F.[5], and NICHOLS, K.M.[1], [1]Department of Biological Sciences, 915 West State St., West Lafayette, IN, 47907; [2]Department of Botany and Plant Pathology, 915 West State St., West Lafayette, IN, 47907; [3]Great Lakes Science Centre, 1451 Green Rd., Ann Arbor, MI, 48105; [4]Department of Forestry and Natural Resources, 195 Marsteller St., West Lafayette, IN, 47907; [5]National Oceaninc and Atmospheric Administration, Great Lakes Environmental Research Laboratory, 4840 S. State Rd, Ann Arbor, MI, 48108. **Patterns of Genetic Diversity in *Diporeia* in the Laurentian Great Lakes.**

The amphipod *Diporeia* once comprised the majority of the benthic biomass throughout the Great Lakes and was historically the major food source for lake whitefish, rainbow smelt, alewives, and slimy sculpins. Since the early 1990s, *Diporeia* populations have experienced dramatic declines while commercial fisheries have concurrently experienced a decrease in production. Various mechanisms and agents have been investigated with no conclusive results, although the studies do indicate that some lake regions are experiencing extreme declines while other regions retain static population levels. These confounding patterns suggest that environmental demands for survival differ across the Great Lakes region and it is possible that the disparities in decline can be explained by differences in species composition. To investigate *Diporeia's* genetic lineages, uncover phylogenetic relationships, and assess population structure across the Great Lakes region, we examined samples collected from 15 sites across the Great Lakes using four mitochondrial genes (COX1, COX3, 16S, and ATP6) identified with the aid of 454 sequencing technology and microsatellite DNA loci designed for *Diporeia*. These preliminary results indicate that Lake Superior represents a distinct lineage from that of the other Great Lakes. *Keywords: Genetics, Diporeia.*

MCCARRY, B.E.[1], SOFOWOTE, U.M.[1], MARVIN, C.H.[2], and ALLAN, L.M.[3], [1]Department of Chemistry and Chemical Biology, McMaster University, Hamilton, ON, L8S 4M1; [2]Aquatic Ecosystem Management Research Division, Environment Canada, Burlington, ON, L7R 4A6; [3]Bruker Daltronics, East Milton, ON, L9T 1Y6. **Sources of Aromatic Hydrocarbons in the Hamilton Harbour Airshed and Watershed.**

The purpose of this work was to identify the number and types of sources of polycyclic aromatic hydrocarbons (PAH) in suspended sediment samples collected in Hamilton Harbour and its tributaries and in inhalable air particulate (PM10) samples collected around the industrial area of Hamilton. Three source apportionment strategies applied to these data sets: (1) PAH

diagnostic ratios, (2) principal components analysis with multiple linear regression (PCA-MLR) and (3) positive matrix factorization (PMF). The goal was to obtain the relative contribution of each PAH source type and to identify the source type by comparison with PAH profiles of authentic sources. Of the three methods, PCA-MLR and PMF and afforded similar factor profiles; the PAH diagnostic ratio approach provided much less useful source discrimination. On the quantitative side, the PMF method afforded consistently better source apportionment results than the PCA-MLR approach. Four major PAH source types were identified in these samples: gasoline engine emissions, diesel exhaust, coke oven emissions and coal tar. Only the first three source types were identified as contributors to the 75 air samples while all four sources were identified in the harbour suspended sediments. This work is a rare example of PMF being used for sediment source apportionment. *Keywords: PAHs, Pollution sources, Sediment quality.*

MCCULLOUGH, G.K.[1] and STAINTON, M.P.[2], [1]Centre for Earth Observations Science, 482 Wallace Bldg., University of Manitoba, Winnipeg, MB, R3G 1R4; [2]Freshwater Institute, Department of Fisheries and Oceans, 501 University Crescent, Wnnipeg, MB, R3T 2N6.
Mobilization of Phosphorous by Flooding in the Red River Basin.

We attribute a recent near-doubling of phosphorous (P) in L. Winnipeg to a surge in loading associated with increased discharge and flood frequency in one tributary, the Red R. Since 1995, flood frequency (discharge $>1000 \text{ m}^3\text{s}^{-1}$) has been 7 in 10 years, compared to < 3 in 10 years over the previous half century. Above flood stage, median P concentration is twice as high as median P at lower, channel-contained discharge. In tributary streams, both dissolved and particulate P (DP & PP) measured during and soon after the spring freshet is highly correlated with spring peak discharge. In a spatially-distributed data set collected during the spring freshet in one tributary (the La Salle R.) DP concentration was generally higher downstream of extensively flooded reaches than in the headwater branches. We attribute this increase in DP to leaching from flooded fields in the low-relief middle-watershed; the increase in PP may have been due to bank erosion and resuspension of channel sediments. In either case, high discharges contributed to increased P concentrations. This is not inconsistent with the widely held view that increased anthropogenic nutrient loading is driving increased productivity in Lake Winnipeg. However, flooding contributes by mobilizing available soluble P from the watershed. *Keywords: Lake Winnipeg, Floods, Phosphorus, Nutrients.*

MCDANIEL, T., PASCOE, T., WATSON, S., and GUO, J., Environment Canada, 867 Lakeshore Rd E, Burlington, ON, L7R 4A6.
Monitoring in a complex sytem: Water quality in Lake of the Woods and the Rainy River.

As part of a larger program to assess and remediate deteriorating water quality in the Lake Winnipeg Basin, Environment Canada formed the Lake of the Woods Science Initiative in response to concerns regarding excess nutrient loading and cyanobacteria blooms in Lake of the Woods (LOW). LOW is a large, hydrologically, complex international water body spanning the Manitoba, Ontario and Minnesota borders. Rainy River, in the southern region, is a major source of both water and nutrients to LOW, accounting for 70% of its hydraulic load. In conjunction with provincial and state partner agencies, water quality (physical and chemical parameters)

sediment quality and biological indicators are being monitored in Lake of the Woods and Rainy River. Sampling, which began in 2008, has taken place at a total of 33 stations, in early, mid and late summer. Physical properties were measured by YSI profile, while water quality parameters were monitored at three depths: surface, integrated photic zone and bottom. Sediments were monitored at 21 stations for physical and chemical properties and benthic invertebrate community structure. Water quality was also monitored at four transects on the Rainy River from Fort Frances to the town of Rainy River. *Keywords: Monitoring, Nutrients, Lake of the Woods, Water quality.*

MCDONALD, C.P. and URBAN, N.R., Michigan Technological University, Houghton, MI, 49931.
Bayesian test-bed calibration of a mechanistic aquatic biogeochemical model for Lake Superior.

Aquatic ecosystem models, especially those applied in large systems, are often complex yet poorly constrained by measurements, leading to considerable uncertainty surrounding the model output. Yet, a certain level of complexity is often deemed necessary *a priori* to address the scientific and management issues at hand. We demonstrate how a "test-bed" approach can be used in large lakes to maximize assimilation of scarce data. Great Lakes data with the spatiotemporal resolution necessary to accurately calibrate an ecosystem model coupled with a 3-D hydrodynamic model do not yet exist. Intensive sampling campaigns, however, provide high-resolution data over small space and time scales. By implementing the ecosystem model in a simplified spatial framework (1-D), it is possible to rigorously estimate parameter values. Models are calibrated at several sites using Bayesian methods. The results are then synthesized into an optimized parameter vector for the whole lake (3-D) model. Using this approach, a number of model structures may also be implemented to identify the most parsimonious specification. *Keywords: Computer models, Ecosystem modeling, Lake Superior.*

MCDONALD, K. and TONINGER, R., 5 Shoreham Drive, Downsview, ON, M3N1S4.
Cormorants in the city: Double-crested Cormorant management at Tommy Thompson Park.

The management of cormorant colonies is challenging regardless of location, but a colony in Toronto poses unique difficulties. The colony at Tommy Thompson Park is located in a public park in close proximity to recreational venues. Many management tools are not feasible due to the location and public access. Co-nesting Black-crowned Night-Herons and Great Egrets also complicate management. At 7564 nests this is the largest known cormorant colony in the lower Great Lakes. TRCA developed a publicly driven management strategy involving an advisory group comprised of stakeholders and experts, including conservationists, academics and interest groups from across the spectrum, to provide advice and input. The goal of the strategy is to achieve a balance between the continued existence of a healthy cormorant colony and the other ecological, educational, scientific and recreational values of the park. The objectives are to increase public knowledge, awareness and appreciation of waterbirds; deter cormorant expansion and limit further loss of forest; and continue waterbird research. The development of the strategy was transparent, holistic and adaptive and by using applied research public support is gained and

the goal and objectives become more attainable. This approach can be used as a case study for managing cormorants in urban areas *Keywords: Cormorants, Management, Lake Ontario.*

MCGILLIS, A.[1], BRUNTON, A.[1], HELKA, J.[2], and BASSINGTHWAITE, M.[3], [1]Baird & Associates, Oakville; [2]City of Hamilton, Hamilton; [3]Cole Engineering, Markham. **Event-Based and Long-Term Sediment Transport Modelling in a Restored River Channel.**

Windermere Basin has issues associated with low water quality and contaminants due to the accumulation of sediments from the Red Hill Creek and surrounding sources. A consultant team who have developed conceptual designs to turn Windermere Basin into a wetland and its surrounding lands into a passive naturalized recreation area. The wetland will create natural habitat within the basin that would increase the aesthetic appeal of the waterfront and provide additional fish and waterfowl habitat that would support restoration initiatives in Hamilton Harbour. This paper presents development, testing and application of a detailed 3-D hydrodynamic and sediment transport numerical model (MISED). Model simulations represented the existing basin conditions, the preliminary design and the detailed design. The focus of the simulations was to define the form of sedimentation in the study area and related impacts including the possible increase in sediment loads to Hamilton Harbour. A Matlab model of morphodynamic change was also implemented to help optimize the final channel configuration for long-term channel stability. The results are critical to the development of sediment management plans, definition of impacts and mitigation measures. *Keywords: Sediment transport, Hydrogeomorphology, Hydrodynamics.*

MCGOLDRICK, D.J., CLARK, M.G., KEIR, M.J., and BACKUS, S.M., Water Science and Technology Directorate, Environment Canada, 867 Lakeshore Rd. P.O. Box 5050, Burlington, ON, L7R 4A6. **Monitoring contaminants in fishes from the Canadian waters of the Great Lakes: 1977 to 2009 - PCBs to PBDEs.**

Canada's Fish Contaminants Monitoring and Surveillance Program (FCSP) began in 1977 as agreed in the Great Lakes Water Quality Agreement (GLWQA). Under the FSCP, concentrations of legacy POPs, such as PCBs, are measured annually in the tissues of fishes from the Canadian waters of the Great Lakes. Coincident with restrictions on the release of these compounds, the concentrations observed in the tissues of fish declined significantly through the 1980s. Despite these declines, the concentration of total PCBs measured in all lake trout in 2008, with the exception of some specimens caught in Lake Superior, were above the GLWQA target of 0.1 µg/g. While legacy POPs are still prevalent and of concern in the Great Lakes ecosystem, there has been increased interest in monitoring other emerged classes of contaminants. The FCSP began annual monitoring of PBDEs in lake trout from all 4 Canadian Great Lakes in 2006. Mean concentrations of tetraBDEs are highest in trout from Lake Ontario followed in decreasing order by trout from Lakes Superior, Huron and Erie. Retrospective analysis of archived lake trout tissues from Lake Ontario were also used to generate a 10 year temporal trend which showed that PBDE concentrations appear to be declining slowly since their peak in the mid to late 1990s. *Keywords: Pollutants, Fish, Great Lakes basin.*

MCINNES, M.[1], ELLIS, D.A.[2], and WEBSTER, E.[2], [1]Department of Chemistry, Trent University, Peterborough, ON, K9J7B8; [2]Centre for Environmental Modelling and Chemistry, Trent University, Peterborough, ON, K9J7B8.
Measurement and Modelling of Altitudinal Flux of Nonylphenol Ethoxylates to the Atmosphere via Aqueous Aerosol Production.

Nonylphenol ethoxylates (NPEs) are environmentally ubiquitous surfactants. Understanding the mechanisms by which they are transported in the environment is of utmost importance. NPEs are surface active compounds and may therefore be subject to transport via aqueous aerosols. To date, little attention has been paid to this potentially important mechanism of transport. This study investigated the loss of NPEs from a body of water upon aerosol production and the effects of water droplet size on mass transfer from bulk to aerosol phases. Droplets were measured and a predictive algorithm was created to evaluate the saturation point of each droplet size. The mass function was integrated with a model that predicts the flux of varying aerosol droplet sizes above water bodies from the water's surface to 600m. The resulting function predicts a mass flux of NPEs in the atmosphere at various heights above the water. *Keywords: Mathematical models, Contaminant flux, Environmental contaminants, Spray generation, Atmosphere-lake interaction, Surfactants.*

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

A key lesson from terrestrial conservation science is that maps of threats and resources are one important starting point for developing coherent restoration and conservation strategies. All management efforts are tied to specific places, and so we need to know the spatial distribution of human impacts in order to guide effective actions. Here, we outline the Great Lakes Threat Mapping Project, which seeks to merge GIS layers representing each of the major categories of threats to the Great Lakes, ranging from climate change to land-based pollution to exotic species. By synthesizing this information into a single map of cumulative threat levels across the basin, we will provide a new tool to the management community that can aid in

prioritization. Additional comparisons between the spatial distribution of cumulative threats and priority habitats, species of concern, and ecosystem services will also be undertaken. This effort, modeled upon recent global threat analyses for marine waters and rivers, will facilitate coordination of restoration and conservation actions throughout the Great Lakes region. *Keywords: Indicators, Comparison studies, Environmental policy.*

MCKAGUE, K.J.[1] and SCHROETER, H.O.[2], [1]Unit A - 401 Lakeview Dr,, Woodstock, ON, Nt 1W2; [2]68 Parker Dr., Simcoe, ON, N3Y 1A4.
Assembling Climate Datasets to Drive Hydrologic and Water Quality Models in the Ontario Great Lakes Basin.

Climate data, including daily or breakpoint precipitation amounts, air temperature, dew point, solar radiation, and wind speed, are key and sensitive input required by users of all scales of hydrologic, water quality, and agricultural management models. Preparing complete climate datasets to drive such models, however, can be time consuming. This presentation will outline how datafilling procedures for air temperature and precipitation, described by Schroeter et al. (2000), were used and expanded upon to arrive at climate input files suitable for use in the WEPP (Water Erosion Prediction Project) soil erosion hillslope model. Erosion prediction models such as WEPP and RUSLE2 (Revised Universal Soil Loss Equation) need storm intensity data to predict the erosivity of individual precipitation events. Techniques suggested by Arnold and Williams (1989) were used to generate breakpoint precipitation from the datafilled files. Solar radiation, windspeed and dewpoint were also datafilled to meet the input needs of WEPP and other related water quality models The datafilling methods were applied to a total of 15 pilot stations across southern Ontario. Resulting files were tested in WEPP and the output was compared with the original Universal Soil Loss Equation's (USLE) estimates of long-term soil erosion losses. *Keywords: Erosion, Model studies, Water, Climatic data, Sediment load.*

MCKAY, R.M.L.[1], TWISS, M.R.[2], BOURBONNIERE, R.A.[3], SMITH, R.E.H.[4], CARRICK, H.J.[5], BULLERJAHN, G.S.[1], BEALL, B.F.N.[1], DSOUZA, N.A.[1], SAXTON, M.A.[6], and WILHELM, S.W.[6], [1]Department of Biological Sciences, Bowling Green State University, Bowling Green, OH; [2]Department of Biology, Clarkson University, Potsdam, NY; [3]Environment Canada, Canada Centre for Inland Waters, Burlington, ON; [4]Department of Biology, University of Waterloo, Waterloo, ON; [5]School of Forest Resources, Pennsylvania State University, University Park, PA; [6]Department of Microbiology, The University of Tennessee, Knoxville, TN.
Life Under Ice: Insights on Winter Production in Lake Erie.

Surveys of Lake Erie during mid-January (extensive ice cover) through late-March (ice restricted to the eastern basin) of 2009 showed the lake supported moderate to high phytoplankton biomass (2-12 µg/L) dominated by the microplankton size-fraction, which generally accounted for > 80% of Chl a biomass. An April 2009 survey demonstrated that high microplankton biomass persisted into spring. We previously demonstrated microplankton to be dominated by centric diatoms of the species *Aulacoseira* spp. Dissolved nutrient concentrations remained elevated throughout the lake and sub-Redfield N:P molar ratios of seston suggested a P-sufficient phytoplankton assemblage as we have previously described. Whereas the winter assemblage achieved moderate to high rates (2-4 g C/g Chl a/h) of total light-saturated primary

production, variable Chl a biomass and light attenuation coefficients, which ranged from 0.5-1/m, resulted in wide ranging estimates of areal production ($\sim$100-1500 mg C m^{-2} d^{-1}). Rates of primary production were decoupled from microbial activity as bacterial growth was low in winter. Given estimates of export production derived from sediment traps throughout the lake, the winter diatom bloom suggests a potential role promoting the formation of hypoxia in Lake Erie's central basin during summer. *Keywords: Lake Erie, Ice, Phytoplankton.*

MCKINLEY, G.A.[1], BENNINGTON, V.[1], ATILLA, N.[3], DESAI, A.[1], MOUW, C.[1], URBAN, N.[2], VASYS, V.[1], and WU, C.[4], [1]University of Wisconsin - Madison, Center for Climatic Research, Madison, WI, 53706, United States; [2]Michigan Technological University, Civil and Environmental Engineering, Houghton, MI, 49931, United States; [3]University of Wisconsin - Madison, Zoology, Madison, WI, 53706, United States; [4]University of Wisconsin - Madison, Civil and Environmental Engineering, Madison, WI, 53706, United States. **Carbon Cycle Variability in Lake Superior: Physical Drivers and Impacts on the Regional Carbon Budget.**

The CyCLeS (Cycling of Carbon in Lake Superior) project has the goal of quantifying Lake Superior carbon cycling and air-lake carbon fluxes and to place them in the context of regional carbon budgeting efforts by the North American Carbon Program (NACP). We have configured a three-dimensional hydrodynamic model with an ecosystem-carbon module for the Lake, and simulated the circulation and carbon cycle for 1989-2008. Without external inputs, the model is able to capture the observed ecosystem structure as well as the observed open-lake pCO2, net primary productivity (NPP), and other biogeochemical quantities. We use the model to consider the response of lake-wide and basin-scale carbon cycling and air-lake CO2 fluxes to physical climate variability on weekly to interannual timescales and discuss the dominant mechanisms. Using back-trajectory analysis in an atmospheric transport model, we also estimate the influence of seasonal CO2 fluxes from Lake Superior on tall tower atmospheric CO2 measurements occurring in Northern Wisconsin. *Keywords: Ecosystem model, Climate change, Climate variability, Carbon cycle, Model studies.*

MCLAREN, P.[1], SINGER, J.[2], MANLEY, P.[3], and MANLEY, T.O.[3], [1]GeoSea Consulting, Brentwood Bay, BC, V8M 1C5; [2]Earth Sciences, SUNY-Buffalo State College, Buffalo, NY, 14222; [3]Geology Department, Middlebury College, Middlebury, VT, ^05753. **Using Geological Tools to Understand Hydrodynamics and Sedimentation Processes in the Buffalo River and Outer Harbor: A Case Study of Urban River Restoration.**

Side-scan sonar mapping and Sediment Trend Analysis (STA) have improved our understanding of sediment sources and sedimentation processes in and around the mouth of the Buffalo River and in the Outer Harbor. STA and side-scan sonar confirmed the presence of a bidirectional flow regime. During times of high flow, a river-dominated transport regime exists; times of lower flow appear to coincide with Lake Erie seiches producing a seiche-driven transport regime capable of carrying sediment 4.5 km upriver. An STA around the river mouth identified four Transport Environments (TE). TEs 1-3 were northwards into the Niagara River; TE4 indicated that sediment from outside the river mouth was moving upriver, as well as

circulating to join the directions of sediment movement found in the adjoining TEs. The upriver transport regime of TE4 can be explained by Lake Erie seiches entraining sediment previously deposited in Buffalo Harbor from the river at times of high flow. In the Outer Harbor, sedimentation patterns derived from STA were correlated to side-scan sonar records used to evaluate bottom morphology and the presence of sedimentary features. Management decisions for river restoration should take into account the influence of Lake Erie seiches and the upriver transport of sediment deposited around the river mouth. *Keywords: Hydrodynamics, Sediment transport, Remediation.*

MCLAUGHLIN, C., Dofasco Centre for Engineering and Public Policy, McMaster University, Hamilton, ON, L8S 4K1. **You Can Do It, We Can Help: Coherent Leadership for Renovation of the Great Lakes Water Quality Agreement.**

To renovate is to make as if new again. The initial Great Lakes Water Quality Agreement was a triumph of binational water governance that instigated pronounced water quality improvements through its processes and institutions. Those processes and institutions have been undermined and diminished, however, and Great Lakes governance anchored by the Agreement has fallen behind modern innovations in water management and policy that better reflect the complex adaptive character of regional social-ecological systems. Continuing uncertainties and new threats to the Great Lakes make the announced renewal of the Agreement imperative, but where governance reflects a collective state of mind, a lack of coherent leadership questions the potential of such innovations to be realized. This presentation highlights results of a study to examine the tools and materials necessary for a successful renovation of the Agreement and the institutional state of mind necessary to undertake it. *Keywords: Great Lakes basin, Leadership, Policy making, Great Lakes Water Quality Agreement, Decision making.*

MCLAUGHLIN, R.[1], JONES, M.[2], MANDRAK, N.[3], STACEY, D.[4], and COTE, J.[4], [1]Department of Integrative Biology, University of Guelph, Guelph, ON, N1G 2W1; [2]Department of Fisheries and Wildlife, Michigan State University, East Lansing, MI, 48824-1222; [3]Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, Burlington, ON, L7R 4A6; [4]Department of Computing and Information Science, University of Guelph, Guelph, ON, N1G 2W1. **FishMaP: A Web Application Supporting Science-Based Decisions Concerning Fish Movement and Passage.**

This presentation will highlight the Fish Migration and Passage (FishMaP) knowledge base (http://fishmap.uoguelph.ca/) – an on-line tool summarizing migration and passage biology of fishes in the Laurentian Great Lakes. Our objectives will be to (i) bring the knowledge base to the attention of a wider group of potential users, (ii) encourage data sharing, and (iii) solicit feedback on content and design. FishMaP allows users to obtain a fish species list by selecting a tertiary watershed, a tributary name, a fish faunal region with a lake, or a custom species list selected from a list of species inhabiting the Great Lakes basin. For that species list, the knowledge base summarizes information on conservation designations, rarity, propensity to inhabit lotic environments, migratory tendencies, sensitivity to barriers and fast flows, use of fishways and culverts, and swimming performance. Users can select reports summarizing

information about each species under a specific topic (e.g. migratory tendencies) or summarizing information about each topic for a given species. Within report types, information can be organized by common or scientific species names. Records summarized in each report topic are referenced back to literature sources. FishMaP was developed to help reach more informed decisions regarding dams and fishways. *Keywords: Decision making, Data storage and retrieval, Fish behavior.*

<u>MCMILLAN, A.M.</u>, Buffalo State College, 1300 Elmwood Ave., Buffalo, NY, 14222.
Botulism in the Great Lakes: using a novel approach to track disease impacts on bird populations.

In the last decade thousands of waterbirds have died from Type E botulism poisoning in the Great Lakes. The impacts of botulism are especially severe during fall migration, when many waterbirds stage on the Great Lakes during their flight south. Common Loons are particularly hard hit; their fall migration corresponds to lake turnover, the time when botulism toxin seems to be most available in fish and invertebrates. Since it was recognized in 1999, it is estimated that botulism poisoning has killed 500 to more than 2,500 loons each year. This study was undertaken to determine which loon populations were being impacted by botulism deaths and whether we could track these impacts using population genetic assays of dead birds. Between 2001 and 2006, feather or muscle tissues from > 250 dead loons were collected along the shores of Lakes Erie and Ontario and analyzed at five polymorphic microsatellite loci. Genetic analysis indicates that loons dying from botulism on Lakes Erie and Ontario are originating from breeding sites directly north of these lakes. These birds are genetically very different from loons breeding both west and east of the Great Lakes. Over the course of the outbreak, however, genotypes have not changed in dead birds. These results will be discussed in light of overall ecosystem health and environmental change. *Keywords: Genetics, Avian ecology, Ecosystem health.*

<u>MCNINCH, R.M.</u> and DREELIN, E.A., 1405 South Harrison Road, 301 Manly Miles Building, Michigan State University, East Lansing, MI, 48824.
Landuse Trends Surrounding Michigan Great Lakes Beaches Based on Annapolis Protocol Classifications.

Using the State's *Escherichia coli* database compiled from recreational beach monitoring, 61 Michigan Great Lakes beaches have each been assigned an Annapolis Protocol (AP) class (5 class levels ranging from A being 'good' to E being 'poor') based on previous statistical analysis conducted by our group. ArcGIS software was used to analyze landuse patterns within the surrounding watersheds of these sampling site coordinates at three scales: 1) entire watershed (HUC12), 2) 1km contributing area upstream of site, and 3) 5 km contributing area upstream of site. Landuse was analyzed at each scale for the entire watershed/contributing area as well as for 50 and 125 meter buffered sections around rivers and streams within each area. The 1km contributing area analysis indicates a high percentage of wetland (61.64%) and urban (70.93%) landuse surrounding 'good' and 'poor' sites, respectively, a trend not noticeable at the watershed scale and indicating scale as an important factor when conducting such landuse analysis. Aerial imagery is now being incorporated to further conduct the analysis in regard to entire beach areas

as a means of more accurately depicting the scale most relevant for investigating pollution sources at beach sites. *Keywords: GIS, Landuse, Water quality.*

MELYMUK, L.E.[1], ROBSON, M.E.[2], DIAMOND, M.L.[2], BACKUS, S.[3], and BRADLEY, L.[3], [1]Dept. of Chemical Engineering and Applied Chemistry, University of Toronto, 200 College Street, Toronto, ON, M5S 3E5; [2]Dept. of Geography, University of Toronto, 100 St. George Street, Toronto, ON, M5S 3G3; [3]Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6.
Urban Sources and Loadings of Organic Contaminants to Lake Ontario: assessing the influence of precipitation from urban and rural sites.

Wet deposition is a significant pathway for loadings of organic contaminants to the Great Lakes. This pathway has been examined through comparisons of concentrations in precipitation of PCBs, PAHs, OCPs, and BFRs at three sites on the north shore of Lake Ontario, one rural (Point Petre), one suburban (Burlington), and one urban (Toronto) site. Concentrations of PAHs, PBDEs, and PCBs in precipitation are significantly higher at the urban site and while this may impact the urban region, this influence does not extend significantly downwind of the urban area. Concentrations in precipitation appear to be the result of local/regional sources rather than long-range transport from other regions. However, despite the limited influence of the urban region on downwind atmospheric deposition of POPs, there are a number of highly urbanized regions adjacent to the Great Lakes, and estimates of loadings via precipitation to lakes are higher when urban concentrations are considered. *Keywords: Urban areas, PBTs, Lake Ontario.*

METCALFE, B.[1], JOHNSON, T.[1], YUILLE, M.[2], HOYLE, J.[3], and BROUSSEAU, C.[4], [1]Glenora Fisheries Station, Aquatic Research and Development Section, Ontario Ministry of Natural Resources, 41 Hatchery Lane, R.R. #4, Picton, ON, K0K 2T0; [2]Department of Biology, Queens University, 116 Barrie Street, Kingston, ON, K7L 3N6; [3]Glenora Fisheries Station, Lake Ontario Management Unit, Ontario Ministry of Natural Resources, 41 Hatchery Lane, R.R. #4, Picton, ON, K0K 2T0; [4]Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, 867 Lakeshore Road, PO Box 5050, Burlington, ON, L7R 4A6.
Assessing Nearshore Fish Communities In Eastern Lake Ontario, Canada.

Freshwater nearshore habitats and fish communities are often more complex and diverse than their pelagic neighbours, and these nearshore fish communities can contribute substantially to a lake's overall fish biodiversity and abundance. Nearshore fish communities are also often the first to experience effects of, for example, non-indigenous species introductions, or habitat degradation. As a result, changes in nearshore fish communities can have substantial implications for entire lake ecosystems. Fishery monitoring programs in the nearshore zones of lakes often target large-bodied fish, and small-bodied fish tend to receive much less attention. We wish to examine which gear types and level of effort are required to adequately describe nearshore fish communities in Great Lakes environments, with an emphasis on small-bodied fish. We sampled the nearshore fish community at several locations in eastern Lake Ontario using six-foot trapnets, three-foot fyke nets, small-mesh gillnets, and three-pass boat electrofishing. Comparisons will highlight similarities and differences in species richness

amongst the four methodologies used, and recommendations for sampling nearshore fish communities will be made. *Keywords: Assessments, Lake Ontario, Littoral zone.*

MEYER, T. and WANIA, F., 1265 Military Trail, Toronto, ON, M1C 1A4. **Transport of organic pollutants within an urban watershed during snowmelt.**

A field study was implemented to investigate the transport dynamics of several pesticides and polycyclic aromatic hydrocarbons (PAHs) in the Highland Creek watershed within the city of Toronto, Canada, during two snowmelt periods. The watershed comprises residential, commercial and industrial areas and a section of "the busiest highway of North America". Water was sampled repeatedly during the snow melt period at different locations along the river and the dissolved and the particulate fractions were separately extracted and analyzed by GC-MS. High water run-off rates at the onset of melting correlate with high concentrations of suspended particulate matter and particle-bound PAHs. While background concentrations of the sum of 9 PAHs ranged between 20 and 50 ng/L, concentrations at the onset of melting varied from 550 to 4500 ng/L. PAHs that had previously been deposited around the watershed are released during strong melt events and flushed into the streams. Relatively water soluble pesticides mainly released from snow packs, tended to appear in river water also early during melting. The mode of melt water ablation from the snow pack to the stream, i.e. overland flow vs. sub-surface flow, may determine whether contaminant peak releases from the snow pack coincide with similar peak loads in river water. *Keywords: PAHs, Snowmelt, Urban watersheds, Pesticides.*

MIDA, J.L.[1], SCAVIA, D.[1], JUDE, D.J.[1], SCHAEFFER, J.S.[2], and WARNER, D.M.[2], [1]University of Michigan School of Natural Resources and Environment, Dana Building, 440 Church St., Ann Arbor, MI, 48109; [2]USGS Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105. **The Role of *Mysis* in Pelagic Food Webs of Lakes Michigan and Huron.**

The opossum shrimp (*Mysis diluviana*, formerly *M. relicta*) is an important part of Great Lakes food webs, but its role may be changing following ecosystem changes. We investigated the new role of *Mysis* in these food webs, with a focus on their availability and quality as a prey item for forage fishes. We investigated and compared *Mysis* abundances, nutritional condition, and relative importance as a prey item for pelagic forage fishes in Lakes Michigan and Huron in 2007 and 2008. *Mysis* nutritional condition was assessed by analyzing total lipid content and fatty acid methyl esters (FAMEs) of samples of *Mysis* tissue collected from the study areas. *Mysis* densities and size metrics were determined by counting and measuring samples taken from vertical tows. Fishes for diet studies were obtained using midwater trawls performed during acoustic surveys. Results of lipid and FAMEs analyses indicate that on average, *Mysis* in Lake Huron have low total lipids and elevated concentrations of DHA, suggesting that they may be food-limited. Preliminary results of fish diet analyses show that *Mysis* are an important prey item for bloaters in both lakes and for rainbow smelt in Lake Huron, although occurrence of *Mysis* in diets decreased from 2007 to 2008. *Keywords: Fish diets, Mysids, Crustaceans, Food chains.*

MIDWOOD, J.D. and CHOW-FRASER, P., McMaster University, 1280 Main St. W., Hamilton, ON, L8S 4K1.
Changes in Fish Habitat and Community Composition in Response to Low Water Levels in Eastern Georgian Bay Coastal Marshes.

Over the past 10 years, water levels in eastern Georgian Bay, Lake Huron have been near the record low of the 1930s. Low water levels can alter both the structure and distribution of aquatic macrophytes, which changes the type and amount of fish habitat available. In this study we found a significant decrease in available fish habitat following a net decline in water level of 10 cm (mean -1181.5 m^2). There was also a change in the complexity of the remaining habitat from one dominated by many small patches of dense vegetation with intermittent sections of less dense areas, to wetlands dominated by uniform high density vegetation. We then assessed fish-community responses to changing vegetation habitat using 38 wetland-years of data, collected between May and August (from 2003 to 2009). In general, there was a significant decline over time in species richness (paired t-test; prob>0.0001; mean -5.6±1.0 per wetland). At the species level, there were significant increases in the proportion of catch of bowfin (*Amia calva*) and pumpkinseeds (*Lepomis gibbosus*) (paired t-test; prob>t=0.0004 and 0.0007, respectively). Our results suggest that sustained low water levels can reduce the complexity of coastal marsh habitat and lead to a less diverse fish community. *Keywords: Fish, Habitats, Coastal wetlands.*

MIER, J.M. and GARCIA, M.H., Ven Te Chow Hydrosystems Laboratory - University of Illinois at Urbana-Champaign, Civil and Environmental Engineering Dept., 205 N. Mathews Ave., Urbana, IL, 61801, USA.
Laboratory Tests on Critical Shear Stress for Erosion of Glacial Till from the St. Clair River (Great Lakes Basin).

In order to assess the variations in water levels observed in Lakes Michigan and Huron (USA-Canada border) during the last few decades, a comprehensive study involving climatic, hydrologic and hydraulic factors is being conducted at the International Great Lakes. It has been proposed that changes in conveyance in the St. Clair River could be contributing to lowering the lake water level. Sediment transport processes can affect significantly the water-carrying capacity of a river, consequently the erodibility characteristics of the River bed needs to be considered. Several samples from the St. Clair River bed sediment (known as glacial till) have been tested in order to obtain the value of the critical shear stress needed to erode the material. An open-channel flume was used for the experiments, where samples were placed inside a custom-built sediment box simulating the bottom of the river. Different flows with increasing velocities were run in the flume up to the point where significant erosion was observed in the sediment sample. Velocity profiles were taken using a Laser Doppler Velocimetry system (LDV), so that shear stress calculations could be performed by fitting a logarithmic law to the bottom part of the profiles. A value of 4.2 N/m^2 was obtained as the critical shear stress for erosion of the glacial till. *Keywords: Shear stress, Laser Doppler velocimetry (LDV), St. Clair River, Glacial till, Sediment transport.*

MILITO, J.[1] and NURNBERG, G.K.[2], [1]Bright Lake Association, Ironbridge, ON; [2]Freshwater Research, 3421 Hwy 117, Baysville, ON, P0B 1A0.
Cyanobacteria Blooms in Bright Lake, Ironbridge, ON: How a Lake Association Tries to Clean up its Lake.

Cyanobacteria blooms have been reported more frequently in recent years, even in remote lakes. Bright Lake (16 km2, 11 m max. depth) is a polymictic lake on the Canadian shield in Northern Ontario, where residents have observed such trends. In 2009, half of the 107 residents formed the Bright Lake Association, Inc., to address increasing concerns about these blooms and ask scientific partners to develop a sustainable approach to remediation. Preliminary investigation identified two main phosphorus (P) sources, agricultural input from streams and internal load released from sediments to facilitate these blooms. A study is being developed to quantify these loads as the first step towards potential remediation. Members of the Lake Association have collected water and sediment samples so that P release rates can be computed and modelled. They have measured oxygen and temperature profiles and found that Bright Lake becomes hypoxic and anoxic during late summer and fall. The remediation of remote lakes such as Bright Lake may be especially important in the context of its location within the general watershed. Its outlet drains into the Mississagi River which is a large tributary to Lake Huron, where deteriorating water quality and cyanobacteria blooms in the Northern Channel have become a notorious issue. *Keywords: Remediation, Eutrophication, Lake management.*

MILLIGAN, M.[1], VALENTIN, L.[1], SIMPSON, S.[1], PAGANO, J.[2], XIA, X.[3], CRIMMINS, B.[3], HOLSEN, T.[3], and HOPKE, P.[4], [1]SUNY Fredonia, Department of Chemistry, Fredonia, NY, 14063; [2]SUNY Oswego, Environmental Research Center, Oswego, NY, 13126; [3]Clarkson University, Department of Civil and Environmental Engineering, Potsdam, NY, 13699; [4]Clarkson University, Department of Chemical Engineering, Potsdam, NY, 13699. **PCDD/F and Coplanar PCB Toxic Equivalency (TEQ) Analysis of Great Lakes Fish.**

As part of the Great Lakes Fish Monitoring Program (GLFMP), we are analyzing whole fish composites collected from all five of the Great Lakes for a suite of legacy and emerging contaminants. One objective is to assess the contributions of coplanar PCBs and 2,3,7,8-substituted chlorinated dioxins and dibenzofurans (PCDD/F) to the overall dioxin-like toxicities (TEQs) in Great Lakes fish tissue. Fish tissue samples were analyzed for twelve coplanar PCBs identified by the World Health Organization (WHO) and seventeen 2,3,7,8-substituted PCDD/F congeners. Although the total coplanar PCB concentrations vary significantly from lake to lake, the fractional composition profiles are virtually identical in all samples. For PCDD/F, the absolute concentrations also vary by lake, but the fractional congener profiles do not agree to the extent that is seen with the coplanar PCBs. In terms of total TEQ, Lake Ontario Trout had the highest concentrations, while Lake Erie Walleye had the lowest. The relative contributions to TEQ from PCBs vs. PCDD/F are quite different from lake to lake. For example, the PCDD/F congeners make up a significant fraction of the total TEQ in L. Ontario fish (34%) but a negligible fraction (4%) in the more PCB contaminated L. Michigan fish. *Keywords: Environmental contaminants, Fish toxins, PCBs.*

MINNS, C.K.[1], DOKA, S.E.[2], MOORE, J.E.[3], and ST. JOHN, M.[4], [1]Dept. Ecology and Evolutionary Biology, Univ. Toronto, 25 Willcocks Street, Toronto, ON, M5S 3B2; [2]Great Lakes Laboratory of Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, P.O. Box 5050, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [3]JEMSys Software Systems Inc, 22

Marion Crescent, Dundas, ON, L9H 1J1; [4]Toronto and Region Conservation Authority, 5 Shoreham Dr, Downsview, ON, M3N 1S4.
Temporal trends and spatial patterns in the temperature and oxygen regimes in the Bay of Quinte, Lake Ontario, 1972-2008.

Summer temperature and oxygen profiles have been monitored since 1972 at offshore sites in the Bay of Quinte, Lake Ontario. In 2001 temperature loggers were added at onshore and mid-channel sites. Here we assess the role of morphometry, climate, nutrient management, and invasion by driessenids in temporal trends and spatial patterns. Peak surface temperatures and vertical stability have increased and higher levels are correlated with mean summer air temperature. In the shallow upper Bay, peak surface temperatures are higher. Onshore sites generally warm earlier in the spring than offshore, reaching similar peak surface temperatures sooner. In the deep lower Bay, the stratification period has lengthened. Oxygen levels in the hypolimnion have not been affected by decreased nutrient loading or the arrival of driessenids. Oxygen depletion continues to be controlled primarily by the length of the stratification period and the degree of hypolimnetic warming induced by seiche activity. Projections based on climate change scenarios indicate that many parts of the Bay of Quinte will undergo substantial warming later in the 21st century. The hypolimnetic oxygen regimes will respond to the warming effects but not reach harmful minima. These changes will shape biotic responses to climate warming. *Keywords: Climate change, Oxygen, Water quality, Temperature, Bay of Quinte, Long-term trends.*

MOLES, M.[1], LA ROSE, J.K.L.[1], and WILLOX, C.C.[2], [1]Ontario Ministry of Natural Resources, Lake Simcoe Fisheries Assessment Unit, 26465 York Rd 18, Sutton West, ON, L0E 1R0; [2]Ontario Ministry of Natural Resources,Southern Science and Information Section, Aquatic Science Unit, 26465 York Rd 18, Sutton West, ON, L0E 1R0.
The Lake Simcoe recreational fishery from 1961 to 2009.

Lake Simcoe is the focus of one of Ontario's largest inland recreational fisheries. The Lake Simcoe Fisheries Assessment Unit (LSFAU) of the Ontario Ministry of Natural Resources, has monitored the fishing effort, catch and harvest of this fishery since 1961 using stratified, roving creel surveys conducted in the summer and winter seasons. This monitoring shows that the total angling effort on Lake Simcoe has generally increased over the past 5 decades, with a recent peak estimated effort of 823,872 hours fishing observed in 2005. A large and growing portion of this fishing effort occurs in the winter season where most anglers target yellow perch, lake whitefish, and lake trout. Summer angling effort is lower, where a more diverse list of species are targeted and caught by anglers. We will review long term trends and the current status of the catch, harvest and effort of the Lake Simcoe sport fishery. *Keywords: Fisheries, Fishing, Lake Simcoe.*

MOORE, D.J.[1] and WESELOH, D.V.[2], [1]Canadian Wildlife Service, Environment Canada, Box 5050, Burlington, ON, L7R 4A6; [2]Canadian Wildlife Service, Environmewnt Canada, 4905 Dufferin St., Toronto, ON, M3H 5T4.
Avian Mortality and Type E Botulism on Islands in Eastern Lake Ontario, 2004-2008.

In recent years, outbreaks of Type E Botulism have occurred in avian wildlife on the Great Lakes. Large scale avian mortality in aquatic settings is often monitored through the use of mainland-based beached bird surveys. In this study, we used island-based beached bird surveys to assess avian mortality up to three times per month on six islands (Scotch Bonnet, Snake, Salmon, Pigeon and False Duck islands and False Duck Shoal) in eastern Lake Ontario. Surveys were conducted from as early as July to as late as November from 2004 to 2008. The purpose of the assessment was to determine the extent of mortality caused by Type E Botulism but other causes were also assessed. The number of dead birds found annually ranged from 550 in 2008 to 2,079 in 2005. The total number of dead birds found in the 5 years was 6,454 and was comprised of 29 species. However, 5 species, Double-crested Cormorant, Herring, Ring-billed and Great Black-backed Gulls and Caspian Tern made up 98.5% of all dead birds found. The four westerly most sites, Pigeon, False Duck and Scotch Bonnet islands and False Duck Shoal each had from 17.7 to 29.1% of the dead birds. The two closest sites to Kingston each had fewer than m6.0% of the *Keywords: Waterbirds, Botulism, Lake Ontario, Mortality.*

MORBEY, Y.E.[1], MOERKE, A.[2], NEFF, B.D.[1], QUACH, K.[1], and SUK, H.Y.[1], [1]Dept. of Biology, University of Western Ontario, London, ON, N6A5B7; [2]Dept. of Biological Sciences, Lake Superior State University, Sault Sainte Marie, MI, 49783.
Population Genetic Structure of Chinook Salmon in Lake Huron.

The large-scale stocking program for Chinook salmon in Lake Huron began in the late 1960's with egg transfers from a single founder population (Green River, Washington). The seven hatcheries operating around Lake Huron have been able to sustain production ever since with adult returns to weirs and fishways. In addition, at least 17 rivers in the Lake Huron watershed have been colonized by Chinook salmon. Based on large-scale tagging studies, it is estimated that wild reproduction now contributes to 85% of the lake-wide population. The recent colonization of multiple streams from a single founder population provides an excellent opportunity to track the dynamics of rapid evolution. We genotyped individuals from 13 streams and 2 hatcheries at eight, variable microsatellite loci to test for population genetic structure. Genetic variation among populations was low indicating an early stage of population differentiation. However, two populations (Maitland River and Nunn's Creek) were slightly differentiated from the others. It may be significant that these two rivers are located at the periphery of the Chinook salmon's range (Maitland River in southwestern Ontario and Nunn's Creek in Michigan's Upper Peninsula). *Keywords: Genetics, Salmon, Lake Huron.*

MORO, D. and TONIGER, R., 5 Shoreham Drive, Downsview, ON, M3N1S4.
Canada Goose Management in the Greater Toronto Area.

Almost extinct by the end of the 19th century, the Canada Goose (Branta canadensis) has made a remarkable recovery. The population has now flourished to the point that it is currently viewed as a nuisance bird. Some factors that have contributed to the population increase include: ideal nesting and moulting habitat, restricted hunting opportunities within the Greater Toronto Area and the long life span of the species. As a result, there are a number of problems associated with this bird in urban environments: fouling of public lands, water quality impairment, aviation

safety concerns and aggressiveness towards humans during the nesting season. From 1998 to 2009, the Toronto and Region Conservation (TRCA) staff initiated a Canada Goose Egg Oiling program within the City of Toronto and neighbouring communities. To date an estimated 2,500 nests containing approximately 10,000 eggs have been treated and has been effective in controlling the local goose population. In addition to reproductive management, TRCA is working with a number of partners to address the problems associated with nuisance geese and has implemented numerous habitat modification projects, relocation programs and undertaken nesting studies to better manage urban geese. *Keywords: Urban areas, Avian ecology, Management.*

MORSE, J.W.[1], BIBERHOFER, H.[2], MACKEY, S.D.[3], GORMAN, A.M.[4], KOCOVSKY, P.M.[5], MACDOUGALL, T.[6], and MARKHAM, J.[7], [1]Oberlin College Department of Biology, 119 Woodland St., Oberlin, OH, 44074; [2]Environment Canada, 867 Lakeshore Rd., Burlington, ON, L7R4A6; [3]Habitat Solutions, 37045 N. Ganster Rd., Beach Park, IL, 60087; [4]Ohio Department of Natural Resources, 1190 High St., Fairport Harbor, OH, 44077; [5]USGS, 6100 Columbus Ave., Sandusky, OH, 44870; [6]Ontario Ministry of Natural Resources, 1 Passmore Ave., Port Dover, ON, N0A1N0; [7]Lake Erie Fisheries Unit, NYDEC, 178 Point Drive North, Dunkirk, NY, 14048.
Constructing a Multi-Scale Database to Identify Spawning Habitat for Lake Trout (*Salvelinus namaycush*) in Lake Erie.

Attempts to reintroduce lake trout to Lake Erie have failed to establish a self-sustaining population in part due to poor understanding of the spawning requirements of the fish and habitat availability. By identifying suitable spawning habitat, a better informed stocking and management program may be able to reestablish this native, keystone species in the eastern basin of Lake Erie. Preexisting GIS data was used to direct RoxAnn and Sidescan Sonar data collection on the primary substrate conditions at potential spawning sites. Underwater video was then collected from these sites, and was used to assess the accuracy of combined GIS and Sonar data in predicting suitable spawning habitat. These data were combined in a multi-scale database providing detailed assessments of substrate conditions in the eastern basin. This database will be used to assess the availability of spawning habitat for lake trout, provide information valuable to the management of other species, and serve as a model for habitat assessment in other lakes. When completed, this database will enable more precisely targeted stocking of lake trout in Lake Erie on the best available spawning habitat to maximize the reproductive success of stocked fish, and will provide a foundation for further study of spawning habitat in the eastern basin. *Keywords: Lake Erie, Sidescan Sonar, Lake trout, RoxAnn, Habitats, Underwater Video.*

MUIR, D.C.G.[1], TEIXEIRA, C.[1], EPP, J.[1], ENGBERS, H.[1], WANG, X.[1], and BACKUS, S.[1], [1]Environment Canada, Aquatic Ecosystem Protection Research Division, Burlington, ON, L7R 4A6; [2]Environment Canada, Water Quality Monitoring and Surveillance, Burlington, ON, L7R 4A6.
Atmospheric deposition and bioaccumulation of selected halogenated organics in remote lakes in Ontario and in the Great Lakes.

The objective of this study was to determine the deposition, concentrations in surface waters, and bioaccumulation, of a wide range of non-legacy halogenated organic compounds

(HOCs) in remote lakes within the Great Lakes basin and in the open Great Lakes. The selected compounds had limited or no measurements particularly in remote lakes. Large volume samples of surface waters (100 L) were collected from Lake Opeongo and Siskiwit Lake (Isle Royale) as well as from surface waters of the lower Great Lakes over the period 2005-2009 using XAD resin columns and 1 um glass fiber filter cartridges. Sediment cores were collected from Lake Opeongo and other lakes in the region. Also collected were zooplankton (>100 um), phytoplankton (~1-100 um), forage fish and lake trout. Samples were analysed for 26 tri- to decaBDEs and 20 brominated and chlorinated organics by GC-negative ion mass spectrometry (MS) using both low and high resolution MS detection. DecaBDE (BDE209), bis(tribromo-phenoxy)ethane (BTBPE), hexabromobenzene, and Dechlorane plus (DP) were the main HOCs detected in sediment cores. These compounds were undetectable in filtered lake water, however, tri-tetra BDEs were present at low pg/L concentrations in all samples. In pelagic food webs, tri-hexa-BDEs predominated along with pentabromoethylbenzene and BTBPE. *Keywords: Bioaccumulation, Flame retardants, Great Lakes basin, POPs, Sediments, Dechlorane.*

MUIR, T., 70 Townsend Ave, Burlington, On, L7T 1Y7. **Future Balancing of Risks and Benefits of Great Lakes Fish Consumption Must be Integrated: Past Approaches are not Protective.**

The contamination of foodstuffs with chemicals, including fish in particular, is universal and presents a conundrum. The benefits of fish consumption, besides providing a high quality source of protein, are largely due to the omega 3 fatty acids associated with health benefits. The contaminants, on the other hand, have been associated in many types of studies with numerous health effects and risks, particularly in birth cohort studies, and there are general indications of possible effects in the population at large. Presently, risk/benefit assessment of fish consumption considers individual chemicals in isolation, and importantly only 3 or 4 are considered. Although there are consumption advisories for certain sensitive populations, these are not legally enforced and do not fully account for measurement uncertainties, or modulating factors such as: in utero and infant exposure; multi-media complex mixtures additivity and synergism; and polymorphisms. Exploring this uncertainty quantitatively found toxicology-epidemiology discordance, and in vitro – in vivo toxicology discordance. Contrasts yielded one to four order of magnitude differences in means between these study types. In vitro data contrasts with epi for DNT by 3 to 4 orders of magnitude and in vivo data contrasts with epi for DNT by up to two orders of magnitude. *Keywords: Fish, Risk and benefits assessment, Environmental contaminants, Fish consumption, Risks, Contaminants.*

MUKHERJEE, M., MCKAY, R.M., and BULLERJAHN, G.S., Bowling Green State University, Department of Biological Sciences, Bowling Green, OH, 43403. **Enumeration of *Actinobacteria* in Lakes Erie and Superior, and Detection of Actinorhodopsin Genes.**

Actinobacteria are common inhabitants of freshwater environments. In particular, the acI lineage of the *Actinobacteria* can dominate bacterioplankton in freshwater lakes. Many such acI bacteria harbor Actinorhodopsins that mediate an alternative form of phototropy. In this study,

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we cultured, identified and performed phylogenetic analysis of 48 actinobacterial isolates from the Great Lakes. We have confirmed that they to belong to *Actinobacteria* by PCR and sequencing. Direct microscopic counts by Fluorescence in situ Hybridization (FISH) revealed that total *Actinobacteria* constitute from 6.5% and 10.6% in Lake Erie and Superior in the summer water samples, whereas FISH counts from the Lake Superior stations showed a marked increase in the number of *Actinobacteria* in the fall, ranging from 43% to 62%. In this study we are employing specific PCR primer sets for the detection and enumeration of Actinorhodopsin genes in environmental samples as well as in the *Actinobacteria* cultured in our laboratory. *Keywords: Photosynthesis, Microbiological studies, Lake Superior.*

MUNAWAR, M.[1], <u>FITZPATRICK, M.</u>[1], NIBLOCK, H.[1], and KLING, H.[2], [1]Fisheries & Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [2]Algal Taxonomy & Ecology, Winnipeg, MB.
A Comparative Evaluation of the Structure and Function of the Planktonic Food Web of Hamilton Harbour Before and During Algal Bloom Conditions.

Hamilton Harbour is a shallow eutrophic embayment of Lake Ontario that has been heavily affected by multiple anthropogenic stressors. Fisheries & Oceans Canada undertook comprehensive spatial surveys of the planktonic food web during the spring and summer of 2006. We examined bacteria, autotrophic picoplankton, heterotrophic nanoflagellates, ciliates, phytoplankton and zooplankton and estimated size fractionated primary productivity and bacterial growth at 12 sites across the bay. An extensive algal bloom was observed during the summer which was dominated by the colonial blue green *Coelosphaerium Naeglianum (Woronchinia Naeglianum)* (2-11 g m^{-3}). Large standing crops of heterotrophic nanoflagellates (0.5-4 g m^{-3}) and zooplankton (0.1-3 g m^{-3}) were also observed under these bloom conditions. The comparatively large biomass of secondary consumers was surprising given that the autochthonous carbon pool was dominated by inedible algae (incl. *C. Naeglianum, Microcystis viridus, Ceratium furcoides*). This paper will consider potential vectors of energy transfer through the planktonic foodweb prior to and during algal bloom conditions. *Keywords: Eutrophication, Ecosystem health, Cyanophyta.*

MUNAWAR, M., <u>NIBLOCK, H.</u>, FITZPATRICK, M., and LORIMER, J., Fisheries and Oceans Canada GLLFAS, 867 Lakeshore Rd, Burlington, ON, L7R 4A6.
The missing carbon link: microbial energy pathways in the Bay of Quinte.

Microbial food web surveys of the Bay of Quinte began in 2000. Bacteria, autotrophic picoplankton (APP), heterotrophic nanoflagellates (HNF) and ciliates were added to the biweekly surveys to provide a more holistic assessment of the lower trophic levels. Patterns in the traditional foodweb will be compared to an expanded microbial food web. Our results show that the microbial loop, and in particular HNF, play a significant role in energy transfer from lower to higher trophic levels. At Belleville, HNF have contributed on average ≈ 500 mg C m-3 to the microbial food web (roughly 35 000 cells ml-1), compared to 700 mg C m-3 for phytoplankton and 120 mg C m-3 for zooplankton based on seasonal weighted means. In some years the contribution of HNF to the organic carbon budget has been higher than phytoplankton and zooplankton combined. But, the re-emergence of algal blooms in recent years of our study,

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have coincided with reduced levels of HNF and a fundamental shift in the structure of the food web from being primarily heterotrophic to being primarily autotrophic. Our research suggests that under algal blooms, HNF provide the primary food resource for zooplankton grazers since the bulk of the algae is inedible. The implications of microbial pathways of energy transfer in sustaining food webs will be discussed. *Keywords: Food chains, Biomonitoring, Bay of Quinte.*

MUNAWAR, M.[1], FITZPATRICK, M.[1], KANE, D.[2], MUNAWAR, I.F.[3], NIBLOCK, H.[1], and LORIMER, J.[1], [1]Fisheries & Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [2]Defiance College, Defiance, OH; [3]Plankton Canada, Burlington, ON. **Application of Ecological Indicators as a Tool for Assessing Beneficial Use Impairments Towards Delisting of the Great Lakes Areas of Concern: Bay of Quinte Example.**

The remediation, restoration and recovery of the Great Lakes Areas of Concern (AOCs) has been the focus of attention for some time, however not much is known about the recovery process due to a paucity of robust, sensitive and rapid indicators of the state of ecosystem health. The evaluation of ecosystem health generally consists of two stages 1) initial screening and 2) intensive research. With the Bay of Quinte as a case study, we evaluated several routine parameters (chlorophyll, primary productivity, nutrient levels etc) as well as integrated, multi-trophic models which may be better indicators of ecosystem change. Furthermore, we propose a battery of tests consisting of phytoplankton biomass, species composition, Vollenweider's phosphorus model and the Planktonic Index of Biotic Integrity (P-IBI). Such holistic indicators are necessary for the determination of Beneficial Use Impairments as well as delisting criteria on a scientifically sound basis. The long term data base of the Bay of Quinte was highly useful in assessing both the impact of multiple stressors and various stages of ecosystem change. Hopefully, the Bay of Quinte experience in dealing with ecological indicators will be applicable for assessing the state of ecosystem health in other Great Lakes AOCs. *Keywords: Remediation, Ecosystem health, Eutrophication.*

MUNAWAR, M., Aquatic Ecosystem Health & Management Society, Fisheries & Oceans Canada, Burlington, on. **Henry Regier: a Scientist, a Leader and a Model for the Future.**

The continuing, long-term contributions of Prof. Henry Regier to Great Lakes science are monumental. His impact is not restricted to North American Great Lakes but extends globally, including his peerless contributions to UNESCO's International Biological Program, Food and Agricultural Organization, UN's Stockholm conference on the Human Environment, as well as many other national and international agencies. Prof. Regier always promoted and encouraged ecosystem-based sciences including his staunch support of the Aquatic Ecosystem Health and Management Society (AEHMS). He has published excellent articles focusing on ecological integrity in the Society's journal and continues to serve on its Emeritus Advisory Board. The Great Lakes research community and the AEHMS are indeed pleased to honour Prof. Regier by convening this tribute session.

MURPHY, S.C.[1], COLLINS, N.C.[1], and DOKA, S.E.[2], [1]University of Toronto at Mississauga, 3359 Mississauga Rd. N., Mississauga, ON, L5L 1C6; [2]Great Lakes Laboratory for Fisheries and Aquatic Science, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Thermal Habitat and Fish Use of Restored Embayments in the Toronto Region.**

Along the shoreline of Toronto, Ontario, a number of small coastal embayments have been constructed or modified to provide recreational opportunities, and to create warmwater fish habitat. The thermal environment of these embayments is complex because of the continual exchange of water with the much larger Lake Ontario. Lake input cools these embayments, and although the degree of cooling varies greatly, they all accumulate fewer growing degree-days ($\sum$GDD) relative to inland lakes. Variation in $\sum$GDD among embayments is greatest during the warming period of the year, and during this period, mean embayment depth explains over 50% of the variability in $\sum$GDD. After mid-summer, the low mean depths of the embayments allow them to cool rapidly below Lake Ontario temperatures, so that inputs from the Lake water warms them. During the cooling season they experience a parabolic decline in water temperatures, interrupted by large, but short-lived drops in temperature from influxes of hypolimnetic waters upwelled from Lake Ontario. The slowed cooling of the embayments in the late-summer and fall is insufficient to compensate for the growing degree-days lost during the heating period. The cooler and more variable temperatures during the spring through mid-summer may delay spawning and reduce growth rates for warmwater fish *Keywords: Urban areas, Lake Ontario, Wetlands.*

MURPHY, S.C.[1], COLLINS, N.C.[1], and DOKA, S.E.[2], [1]University of Toronto at Mississauga, 3359 Mississauga Rd. N., Mississauga, ON, L5L1C6; [2]867 Lakeshore Road, Great Lakes Laboratory for Fisheries and Aquatic Science, Burlington, ON, L7R4A6. **'Sources and Sinks': Using Otolith Microchemistry to Evaluate the Habitat Quality of Coastal Embayments Along the Shoreline of Toronto, Ontario.**

Near the Toronto Harbour a large number of small coastal embayments have been constructed or modified to provide recreational opportunities and to create warmwater fish habitat. However, the quality of the fish habitat created in these embayments has never been evaluated and the degree of fish movements among embayments is unknown. Using otolith microchemistry for pumpkinseed, largemouth bass and yellow perch, we evaluate embayment habitat quality by mapping the metapopulation dynamic of the harbour and identifying bays that produce young-of-the-year fish that successfully survive their first winter. *Keywords: Metapopulation dynamics, Lake Ontario, Otolith microchemistry, Wetlands, Urban areas.*

MURRAY, M.W.[1] and SCAVIA, D.[2], [1]National Wildlife Federation, 213 W. Liberty St., Suite 200, Ann Arbor, MI, 48104, US; [2]School of Natural Resources & Environment, University of Michigan, 440 Church St., Ann Arbor, MI, 48104, US. **Identifying Priority Geographic Areas for Restoration and Protection Via an Expert Opinion Process.**

As part of an effort to focus on-the-ground restoration and protection work of the Healing Our Waters (HOW) – Great Lakes Coalition (a coalition of over 100 mostly nongovernmental organizations (NGOs)), the coalition's Technical Advisory Committee undertook a prioritization process in fall 2009. The expert opinion process involved a workshop with 18 researchers from diverse backgrounds, where general criteria were identified (such as severity of problem, likelihood of risk reduction) and applied to both previously identified geographic areas and new areas recommended by workshop participants. The workshop was followed by a survey of additional researchers to rate geographic areas using similar criteria and organized by broad GLRI stress categories (e.g., toxic chemicals/Areas of Concern, invasive species). Though the number of survey respondents was relatively small, there were a number of similarities between results for other researchers and recommendations of workshop participants, as well as some diverse perspectives (including on new areas). General findings will be presented, as well as a brief summary of strengths and limitations of expert opinion approaches for contributing to priority setting in the Great Lakes. *Keywords: Assessments, Restoration, Planning, Protection, Policy making.*

MURRY, B.A.[1] and FARRELL, J.M.[2], [1]115 Brooks Hall, Mt. Pleasant, MI, 48859; [2]1 Forestry Dr., Illick Hall, Syracuse, NY, 13210. **Body-Size Versus Species Composition Stability in a Large River Fish Assemblage: Implications to Ecosystem Services.**

Temporal stability in the distribution of individuals among species and size-classes has important implications on the reliability of food web-based ecosystem services upon which we depend. Our reliance on the ecosystem services provided by healthy fish assemblages underscores the importance of understanding fish assemblage stability. Using a long-term (1977-2004) nearshore gillnetting survey of the upper St. Lawrence River we developed annual size-spectra of the fish assemblage and evaluated changes in species composition. The structure of the fish assemblage, defined as the distribution of individuals among species, size classes, and/or species in size classes, showed strong patterns over time. The slope (-0.63) of the size-spectra (log mass x log abundance) did not differ (F = 0.61, P = 0.93) over the 28 year period indicating strong stability in assemblage size structure. Similarly, the distribution of individuals among size classes evaluated with Cohen's Kappa (κ) was highly stable ($\kappa = 0.71$) relative to the distribution of individuals among species ($\kappa = 0.19$). We suggest that certain, 'intrinsic or primary', ecosystem services (i.e. supporting services) show higher resistance to change and greater stability than 'secondary' ecosystem services (i.e. cultural services). *Keywords: Species composition, Food chains, Size-spectra, St. Lawrence River.*

MUTER, B.A., GORE, M.L., and RILEY, S.J., Department of Fisheries & Wildlife, Michigan State University, 13 Natural Resources Building, East Lansing, MI, 48824. **Birds of a Feather: Influence of Social Networks on Stakeholder Risk Perceptions Associated with Cormorant Management in Northern Lake Huron.**

The dramatic recovery of double-crested cormorants (*Phalacrocorax auritus*) in the Great Lakes Basin has been accompanied by concerns about the birds' potential risks to the environment, recreation and economy. Contention exists regarding the perceived extent of these

risks within and among the stakeholder groups affected by management. Effects of social networks on stakeholder risk perceptions related to cormorants in northern Lake Huron were studied using a snowball sampling procedure from August 2008 to August 2009. We conducted face-to-face interviews and administered questionnaires with 47 agency professionals (e.g., fisheries and wildlife managers) and 66 non-governmental stakeholders (e.g., anglers, birders and business owners) in the U.S. and Canada. Data were collected about participants' ties (e.g., who they communicate with about cormorants and how often) and their perceived cormorant-related risks. The network was instrumental in disseminating information about cormorants around the Basin. Respondents shared similar attitudes about cormorants; the network is key to creating those similarities. The more frequently two people communicated, the more likely they were to share similar risk perceptions. Cormorant-related risk communication may be improved with consideration of communities and their networks. *Keywords: Cormorants, Human dimensions, Lake Huron, Risk perception, Management, Communication.*

NADDAFI, R. and RUDSTAM, L.G., Department of Natural Resources,, Cornell University Biological Field Station, Bridgeport, NY, 13030. **Lethal and non-lethal effects of predators on exotic dreissenids.**

Predators have both consume prey (lethal effects) and affect prey behavior or habitat choice (non-lethal effects) and both effects can alter the outcome of the prey-resource interactions. We investigated the size of quagga and zebra mussels consumed by predators with different feeding modes (pumpkinseed sunfish, round goby, and rusty crayfish), and how these predators affect the behavior of both mussel species. All predators used a broad size range of dreissenids, but preferred the small mussels. Predators were able to consume larger quagga than zebra mussels but had overall a higher daily consumption rates on zebra mussel than quagga mussels, suggesting predation may somewhat contribute to the replacement of zebra mussels by quagga mussels. Both mussel species exposed to cues from predators attached stronger to the substrate and preferred refuge habitat. For a given size, the attachment strength was higher in zebra mussels than quagga mussels. Dreissenids aggregated more in the presence of predators, and this effect was stronger for zebra mussels than quagga mussels. Dreissenids movements were also affected by the presence of predators. Both lethal and non-lethal effects of predators are likely important for the dynamics of the two dreissenid species and consequently for the effects on the ecosystem. *Keywords: Pumpkinseed sunfish, Predation, Rusty crayfish, Dreissena, Round goby, Non-lethal effect.*

NALEPA, T.F.[1], FANSLOW, D.L.[1], RINCHARD, J.[2], HÖÖK, T.O.[3], and RYAN, D.J.[3], [1]Great Lakes Environmental Research Laboratory, NOAA, 4840 S. State St., Ann Arbor, MI, 48108; [2]State University of New York-Brockport, 350 New Campus Drive, Lennon Hall, Brockport, NY, 14420; [3]Purdue University, 715 W. State St., West Lafayette, IN, 47907. **Variation in Lipid Content of Diporeia spp. across the Great Lakes and in Cayuga Lake.**

A common hypothesis for the decline of *Diporeia* is that it is being outcompeted for available food by *Dreissena*,leading to decreased numbers and eventual extirpation. Total lipid content, lipid classes, and fatty acid composition in *Diporeia* vary with food availability, and

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therefore offer a means to assess the role of food limitation in population declines. In 2008, we measured these variables in individuals collected in spring and summer from each of the Great Lakes except Lake Erie, and also in individuals collected from Cayuga Lake (Finger Lake). *Diporeia* is declining in Lakes Michigan, Ontario, and Huron where *Dreissena* is abundant and expanding, not declining in Lake Superior where *Dreissena* distributions are limited, and not declining in Cayuga Lake where *Dreissena* is abundant. Mean total lipid level (% dry weight) varied from 20.9 % (Lake Superior) to 31.2 % (Cayuga Lake), and did not appear related to population status. Lipid content was greater in adults (>5 mm) compared to juveniles (<5 mm) in all the lakes except Lake Michigan. Triglycerides and phospholipids were the dominant lipid classes, accounting for 77% (Lake Huron) to 94% (Cayuga Lake) of total lipid. Based on lipids, populations are the most food-limited in Lake Superior and least food-limited in Lake Cayuga. *Keywords: Zoobenthos, Diporeia, Benthos.*

NELSON, H.[1], SIERACKI, C.K.[1], and HUNT, C.[2], [1]Fluid Imaging Technologies, 65 Forest Falls Drive, Yarmouth, ME, 4096, USA; [2]Battelle, 397 Washington Street, Duxbury, MA, 2332. **In situ Characterization of Phytoplankton Communities using a Novel Submersible Imaging Flow Cytometer.**

The study of plankton dynamics is limited by a lack of data at the appropriate temporal and spatial scales. This is in part due to the lack of robust, sensitive in situ tools that can continuously characterize plankton communities, forcing researchers to depend on limited data measured by labor intensive laboratory methods or reliance on surrogate parameters. Research and monitoring in ocean and coastal regions and water supply reservoirs would also benefit from an ability to quantify and characterize plankton on a continuous basis. To address research, ocean observing, and water resource measurement needs, we have adapted a well established, commercially available digital imaging flow cytometer, the Fluid Imaging Technologies' FlowCAM, for in situ deployment. The new Submersible FlowCAM model retains the capabilities of the popular FlowCAM bench top instrument and can operate autonomously at depths to 200 meters under user controlled operations. The unit characterizes the morphology, chlorophyll, and forward scatter of 20 to 300 micrometer particles. It takes an image of every analyzed particle for further analysis and cell identification by the user. While the submersible FlowCAM is primarily designed for deployment on moorings, it can also be operated in a profiling mode. This talk describes this new instrument. *Keywords: Algae, Buoys, Plankton.*

NEWSTED, J.L.[1], MOORE, J.[2], BURSIAN, S.[2], FITZGERALD, S.[2], GIESY, J.P.[3], LINK, J.[2], KAY, D.[1], and ZWIERNIK, M.[2], [1]Entrix, Inc., Okemos, MI, 48864; [2]Michigan State University, Department of Animal Science, East Lansing, MI, 48824; [3]University of Saskatchewan, Department of Biomedical and Veterinary Biosciences and Toxicology Centre, Saskatoon, SK, S7J 5B3. **The Effects of TCDD, PeCDF and TCDF on Development of Maxillary and Mandibular Squamous Epithelial Proliferation in Mink.**

Mink (Neovison vison) were exposed to environmentally relevant concentrations of 2,3,4,7,8-pentachlorodibenzofuran (PeCDF), 2,3,7,8-tetrachlorodibenzofuran (TCDF) or 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) to evaluate effects on reproduction and on mandibular and

maxillary squamous epithelial proliferation, sensitive biomarker of dioxin-like chemicals,. Treated diets were fed from 2 months prior to breeding through weaning of offspring at which time the adult females and a subsample of 6-wk-old kits were necropsied. Surviving kits were maintained on their respective diets through 27 wks of age and then were necropsied. While reproduction and kit survival and growth were minimally affected, robust dose-response relationships between mandibular and maxillary squamous epithelial proliferation was noted in kits and juveniles. Doses resulting in 50% incidence of this lesion in juvenile mink were 9.8 ng TEQTCDD/kg bw/d, 21.02 ng TEQTCDF /kg bw/d, and 6.2 ng TEQPeCDF /kg bw/d. Relative potency values for TCDF and PeCDF compared to TCDD were 0.05 and 0.47, respectively. These data support the fact that the mammalian-specific toxicity equivalency factors (TEFs) values for these furans are overly conservative and that this jaw lesions can be used as a biomarker in mink for dioxin-like compounds in the Great Lakes. *Keywords: PCBs, Mink, Biomarkers.*

NEWTON, T.J.[1], VAUGHN, C.C.[2], SPOONER, D.E.[3], and NICHOLS, S.J.[4], [1]U.S. Geological Survey, Upper Midwest Environmental Sciences Center, LaCrosse, WI, 54603; [2]Oklahoma Biological Survey, Department of Zoology, University of Oklahoma, Norman, OK, 73019; [3]Trent University, Department of Biology, Peterborough, ON, K9J 7B8; [4]U.S. Geological Survey, Great Lakes Science Center, Ann Arbor, MI, 48105. **Understanding the Role of Unionid Mussels in Riverine Food Webs Using Biochemical Tracers.**

As large, long-lived filter feeders, unionids are capable of altering nutrient cycling in riverine food webs. Unionids create a nutrient shunt, removing suspended particles and associated nutrients to the substrate where they are available to other biota. Nutrients can also be sequestered into biomass and removed from the food web. The magnitude of this effect is largely a function of density and biomass. Recent continental declines in unionid populations represent a significant reduction in benthic filter-feeding biomass that may alter ecosystem function. We used biochemical tracers (e.g., stable isotopes, fatty acids) to track nutrient assimilation in unionids across dense and diverse mussel assemblages in 4 North American rivers. Stable isotope analyses yielded ambiguous results suggesting that either additional highly ^{13}C depleted foods (e.g., methanotrophic bacteria) had been consumed or that unionids were selectively assimilating ^{13}C depleted fractions from a heterogeneous FPOM pool. We observed considerable variation in essential fatty acids (EFA) across rivers, but EFA profiles were consistently dominated by arachidonic acid. Recovery of native unionid communities may help re-establish their roles in riverine food webs (e.g., nutrient cycling) to the benefit of restoration efforts. *Keywords: Mussels, Bioindicators, Food chains.*

NGHIEM, S.V.[1] and LESHKEVICH, G.[2], [1]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive MS 300-227, Pasadena, CA, 91109; [2]NOAA/Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108. **Advancing a Satellite Synthetic Aperture Radar (SAR) Ice Classification Algorithm for RADARSAT-2 Data.**

This presentation describes the advancement of a freshwater ice classification algorithm for use with RADARSAT-2 polarimetric data. The high resolution of satellite synthetic aperture radar (SAR) measurements with its all-weather, day/night sensing capabilities make it well suited to map and monitor Great Lakes ice cover. Using our library of calibrated polarimetric SAR ice backscatter signatures, an algorithm was developed to classify and map major Great Lakes ice types. 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. RADARSAT-2 polarimetric data collected in 2009 coincident with in situ measurements on Lake Superior reveal that although single-polarization backscatter data can be used to map different ice types, multi-polarization backscatter data is better to map ice types and open water without the ambiguity encountered in single polarization data due to variations in wind speed and wind direction over water. *Keywords: Remote sensing, Ice, Lake Superior.*

NICHOLAS, J.R.[1], MCKENNA, J.E.[2], REEVES, H.W.[1], SEELBACH, P.S.[3], and STEWART, J.S.[4], [1]U.S. Geological Survey, Lansing, MI; [2]U.S. Geological Survey, Cortland, NY; [3]Michigan Department of Natural Resources and Environment, Ann Arbor, MI; [4]U.S. Geological Survey, Madison, WI. **Great Lakes Basin Framework for Ecological Flow.**

The Great Lakes Region can benefit from a consistent scientific framework for ecological flow discussions. USGS is working with state partners to develop a U.S. Great Lakes Basin framework which incorporates models that relate changes in landscape and hydrologic variables, especially water withdrawals, to changes in ecosystem function. The framework is analogous to that developed in Michigan to support state implementation of the Charter. The NHDplus is the geospatial basis for the framework. Every stream reach in the U.S. Great Lakes Basin will be populated with estimates of streamflow, hydrogeologic properties, and ecological response curves. *Keywords: Great Lakes basin, NHDplus, Ecosystem modeling, Watersheds.*

NICHOLLS, K., S-15 Concession 1, RR#1,, Sunderland, ON, L0C 1H0. **The Phytoplankton of the Bay of Quinte, 1972-2008: Point-source Phosphorus Loading Control, Dreissenid Mussel Establishment, and a Proposed Community Reference.**

The composition and biomass of the phytoplankton of the Bay of Quinte (northeastern Lake Ontario) have been regulated mainly by nutrient status, food web dynamics and physical factors as revealed by multiple regression, clustering and principal coordinates analyses. The inter-annual differences in community structures of the upper and lower Bay of Quinte were less significant than the within-year differences between the upper and lower bays. The relatively shallow and polymictic upper bay facilitated the ice-free period domination of the phytoplankton by diatoms (especially *Aulacoseira* spp) while a more balanced representation by several algal Divisions characterized the thermally stratified, dimictic the lower bay. The Remedial Action Plan phytoplankton objective of 4-5 mm^3 L^-1 (May-October average) has been met frequently since the establishment of *Dreissena*. The post-*Dreissena* period, however, was also characterized by occasional very high biomass of the potentially toxic cyanobacterium (blue-

green alga) *Microcystis*, as well as by the near extirpation of the diatoms, *Tabellaria* and *Synedra* spp. The upper bay phytoplankton communities of recent years have been significantly different from that of a proposed reference community. *Keywords: Rehabilitation, Phytoplankton, Dreissena, Bay of Quinte, Phosphorus.*

NICHOLLS, K.H., S-15 Concession 1,, Rural Route #1, Sunderland, ON, L0C 1H0.
Phosphorus and Chlorophyll in the Bay of Quinte: a Time-series/Intervention Analysis of 1972-2008 Data.

Exploratory and inferential time series analyses were conducted of a 37-year record of total phosphorus and chlorophyll data from the Bay of Quinte, northeastern Lake Ontario. Three largely independent methods were used to build consensus around the significance of the apparent effects of two interventions: (1) point-source phosphorus loading reductions of about 50% to the upper bay in the winter of 1977-78, and (2) the establishment of zebra mussels (Dreissena spp) in the early to mid-1990's. Included were: (a) Non-parametric tests that account for persistence and seasonality and were used to assess the significance of step trends, (b) ARIMA-Intervention modelling that produced forecasts into post-intervention time periods that were compared statistically to measured data, and (c) Regime shift detection for identifying the relative statistical significance of persistent steps or regime shifts, after removal of the seasonal component (modelled as periodic functions). Concurrence among the three methods suggest that the apparent effects of phosphorus loading reductions were more significant in the upper bay, than in the lower bay, but the apparent effects of the Dreissena establishment were less significant in the upper bay than in the lower bay. The RAP objective of 30ug/L has not been met consistently in recent years. *Keywords: Bay of Quinte, Chlorophyll, Phosphorus, Time-series.*

NOLD, S.C.[1], BELLECOURT, M.J.[1], BIDDANDA, B.A.[2], KENDALL, S.C.[2], RUBERG, S.A.[3], SANDERS, T.G.[2], and KLUMP, J.V.[4], [1]Biology Department, University of Wisconsin-Stout, Menomonie, WI, 54751; [2]Grand Valley State University, Muskegon, MI, 49441; [3]NOAA-Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 48015; [4]UW-Milwaukee, Milwaukee, WI, 53201.
Lacustrine Submerged Sinkhole Sediments are a Sink for Organic Carbon.

Submerged sinkholes in Lake Huron differ from the surrounding lake due to the intrusion of cold, dense, hypoxic groundwater that blankets the lake floor. Here, cyanobacterial mats overlay carbon-rich sediments (5-16 weight %C). To better understand nutrient flow through sinkhole ecosystems, we measured the stable isotopic content of carbon and nitrogen in inorganic and organic carbon pools in Middle Island sinkhole, a deep (~23 m) feature influenced by both groundwater and overlying lake water. Two distinct carbon sources were available to primary producers: groundwater DIC differed by -3.6‰ from Lake Huron water DIC. 13C signals in organic carbon pools reflected the two DIC sources. Cyanobacterial mats growing in groundwater were more 13C-depleted than the 13C-enriched phytoplankton growing in lake water. 13C signatures of organic carbon in sinkhole sediments were more similar to sedimenting phytoplankton than to benthic cyanobacterial mats. Corroborated by sediment C/N ratios, these

data suggest that carbon deposited in sinkhole sediments originates from planktonic rather than benthic sources. Additional carbon dating, organic acid, and methane gas data suggest that sinkholes may act as carbon sinks within the larger lake ecosystem. *Keywords: Carbon, Nitrogen, Sediments, Biogeochemistry, Stable isotopes, Groundwater.*

NORRIS, K.D.[1], RIDAL, J.[2], CAMPBELL, L.[1], and HODSON, P.V.[1], [1]Queen's University, Department of Biology, Kingston, ON, K7L3N6; [2]St. Lawrence River Institute of Environmental Studies, Cornwall, ON, K6H4Z1, Canada.
The Distribution and Biomagnification of Mercury in Lake St. Francis.

Previous industrial inputs of mercury into Lake St. Francis have caused it to be designated as an Area of Concern under International Joint Commission's Great Lakes water quality program. Though these industrial inputs have been eliminated for approximately 15 years, mercury concentrations in the lake's walleye are almost twice as high as walleye found upstream, as well as the Ontario Ministry of the Environment have issued advisories about the consumption of these walleye. The goal of this study is to determine if the high concentrations of mercury in walleye are due to transfer from contaminated sediments, from past industrial inputs, or other uncontrolled sources. Sediment, pore water, amphipods and yellow perch were collected from 27 sites around Lake St. Francis to describe the geographical distribution of mercury and methyl mercury as an indicator of potential sources, as well as to assess the pathway and extent of mercury biomagnification. Preliminary results indicate that sediment mercury concentrations are highest just downstream of the city of Cornwall, where the past industrial sources were located. However, yellow perch mercury concentrations were found to be highest further downstream than the highest mercury contaminated sediments. *Keywords: St. Lawrence River, Mercury, Biomagnification.*

NORTH, R.L.[1], BARTON, D.[2], BHAVSAR, S.[3], BORWICK, J.[4], BUMSTEAD, N.[5], CROWE, A.S.[6], DILLON, P.J.[1], DOLSON, R.[7], EVANS, D.O.[8], GEE, K.[9], GEWURTZ, S.[3], GINN, B.[10], HAKANSON, L.[11], HAWRYSHYN, J.[12], HELM, P.[3], HIRIART-BAER, V.[6], JARJANAZI, H.[3], KELLY, N.[13], KING, J.W.[14], LANDRE, A.[3], LA ROSE, J.[7], LEWIS, C.F.M.[15], LIN, Z.H.[1], LONGSTAFFE, F.J.[5], MACDONALD, R.A.[5], METCALFE, B.[16], MILNE, J.[6], MOLES, M.[7], MOLOT, L.[13], OZERSKY, T.[2], QUINLAN, R.[13], RENNIE, M.D.[1], ROBILLARD, M.[17], RODÉ, D.[13], RÜHLAND, K.M.[12], SMOL, J.P.[12], SOLIMAN, C.[1], STAINSBY, E.[3], WESELOH, C.[18], WILLOX, C.[17], WINTER, J.G.[3], YAN, N.[13], and YOUNG, J.D.[3], [1]Trent University, 1600 West Bank Drive, Peterborough, ON, K9J 7B8; [2]University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1; [3]Environmental Monitoring and Reporting Branch, Ontario Ministry of the Environment, 125 Resources Rd, Toronto, ON, M9P 3V6; [4]Ontario Ministry of Natural Resources, Aurora District, 50 Bloomington Rd. W., Aurora, ON, L4G 0L8; [5]University of Western Ontario, 1151 Richmond Street, London, ON, N6A 3K7; [6]National Waters Research Institute, Canada Centre for Inland Waters, Environment Canada, 867 Lakeshore Road, P.O. Box 5050, Burlington, ON, L7R 4A6; [7]Lake Simcoe Fisheries Assessment Unit, Ontario Ministry of Natural Resources, Sutton West, ON; [8]Aquatic Research and Development Section, Ontario Ministry of Natural Resources, Trent University, 2140 East Bank Drive, Peterborough, ON, K9J 7B8; [9]Ministry of Natural Resources, Midhurst District, ON; [10]Lake Simcoe Region

Conservation Authority, 120 Bayview Pkwy, Newmarket, ON, L3Y 4X1; [11]Uppsala University, Villavägen 16, S-752 36, Uppsala, Sweden; [12]Queen's University, 99 University Avenue, Kingston, ON, K7L 3N6; [13]York University, 4700 Keele Street, Toronto, ON, M3J 1P3; [14]University of Rhode Island, South Ferry Road, Narragansett, RI, 02882-1197, USA; [15]Geological Survey of Canada Atlantic, Natural Resources Canada, Bedford Institute of Oceanography, Box 1006, 1 Challenger Drive, Dartmouth, NS, B2Y 4A2; [16]Aquatic Research and Development Section, Ontario Ministry of Natural Resources, Picton, ON; [17]Aquatic Science Unit, Southern Science & Information Section, ON Ministry of Natural Resources, 26465 York Rd. 18, Sutton West, ON, L0E 1R0; [18]Canadian Wildlife Service - Ontario Region, 4905 Dufferin St., Toronto, ON, M3H 5T4. **State of Lake Simcoe.**

We will synthesize the state of Lake Simcoe with the intent that lessons from the past become solutions for the future. Ecosystem stressors include climate change, excessive phosphorus loading, increased shoreline development and changes in land-use, invasive species introductions, and increases in fish harvest. Responses to these stressors have been seen in the physical, chemical, and biological components of the lake. For example, there has been an increase in the thermal stability and water clarity of the lake since 1980. Several nutrients (TP, SRP, NH4+) have decreased, while others have increased (Si). Metals and organic contaminants of historical concern have decreased in sediments and in sport fish; however, there are elevated levels of DDE in birds and emerging contaminants in sediments, and chloride concentrations are increasing. The deep water dissolved oxygen minimum has increased significantly, but is still below the target level. Biological observations include high aquatic plant biomass and changes in the biomass and composition of phytoplankton, zooplankton, and benthic invertebrates. The coldwater fish community has shown declines in recruitment, abundance and natural reproduction. There has been some success over the last 30 years but continued efforts towards lake restoration are required. *Keywords: Lake Simcoe, Monitoring, Ecosystem health.*

NURNBERG, G.K., Freshwater Research, 3421 Hwy 117, Baysville, ON, P0B 1A0. **Internal Load and Sedimentation in Phosphorus Mass Balance Models.**

The separation of upward (internal load) and downward (sedimentation) fluxes of phosphorus (P) is challenging and many attempts of simple mass balance modelling are unsuccessful. There are several reasons for such failure:1. Mixing net, partially-net, and gross estimates of internal load. 2. Combining upward with downward P fluxes. Most retention models were developed from lakes with sediment release, so that they incorporate both upward and downward fluxes. A model is necessary that specifically predicts downward fluxes (sedimentation) and has been developed previously on oxic stratified lakes that do not experience sediment P release (Nürnberg 1984). However, other models may be more useful in different lakes (polymictic, hardwater). In most cases, a strict mass balance cannot be expected to predict epilimnetic summer P averages, the variable that is most thought after. For example, the model overestimates in reservoirs with bottom outlet and internal P load; it underestimates in meso- and eutrophic polymictic lakes (with surface outlet) that experience summer P release from sediments. In these cases, a calibration for the specific lake or reservoir is necessary. This approach can be used in large and small lakes and reservoirs. A successful application is

demonstrated for a eutrophic, polymictic reservoir with bottom outlet *Keywords: Lake model, Retention model, Phosphorus, Lake management.*

O'CONNOR, E.M.[1], MCCONNELL, C.[2], LEMBCKE, D.[1], and WINTER, J.G.[3], [1]Lake Simcoe Region Conservation Authority, 120 Bayview Parkway, Newmarket, ON, L3Y 4X1, Canada; [2]Ontario Ministry of the Environment, Dorset Environmental Science Centre, 1026 Bellwood Acres Road, Dorset, ON, POA 1E0, Canada; [3]Ontario Ministry of the Environment, 125 Resources Road, Toronto, ON, M9P 3V6, Canada.
Selecting a loading calculation procedure to estimate total phosphorus loads in rivers: Application to the Black River and East Holland River (Lake Simcoe watershed, Ontario, Canada).

Estimation of nutrient loads is of crucial interest for assessment of water quality. Ongoing research projects aimed at understanding the links between phosphorus loading and biotic impairment in Lake Simcoe require accurate estimates of phosphorus loading to the lake. This study evaluates several phosphorus loading estimation procedures given available streamflow and concentration data for two tributaries of the Lake Simcoe watershed, the Black River and the East Holland River. Determining the best procedure involved the evaluation of several strategies for stratifying the flow and corresponding concentration data into groups. Then the most suitable load estimation method (regression, ratio or averaging method) was applied to stratified data to estimate annual loads. Stratification of data into three groups based on half and two times the mean flow and the Beale Ratio load estimation method were chosen to estimate annual loads for both tributaries. The resultant annual loads were compared to results of the midpoint method, the method used since 1990 to estimate tributary loads to Lake Simcoe. The results of this study will contribute to development of load estimation procedures for other tributaries of Lake Simcoe. *Keywords: Phosphorus, Load, Lake Simcoe, Tributaries.*

O'CONNOR, L.M.[1], STEEVES, T.B.[2], PRATT, T.C.[1], and STEPHENS, B.[2], [1]Fisheries and Oceans Canada - GLLFAS, 1219 Queen Street East, Sault Ste. Marie, ON, ON, P6A 2E5; [2]Fisheries and Oceans Canada - SLCC, 1219 Queen Street East, Sault Ste. Marie, ON, ON, P6A 2E5.
In Situ Assessment of Lampricide Toxicity to Age-0 Lake Sturgeon.

Larval Sea Lampreys are controlled in streams by a chemical larvicide 3-triflouromethyl-4-nitrophenol (TFM). Laboratory and field exposure tests have demonstrated that TFM can also be toxic to caged age-0 Lake Sturgeon (<100 mm). In 2008, we collected age-0 fish from the Mississagi and Aux Sables Rivers and with hatchery reared individuals, used radio telemetry and caged fish to compare their survival to two TFM treatments: a) Sturgeon Protocol, 1.2 x MLC, a TFM treatment regime that is designed to have reduced toxicity to age-0 Lake Sturgeon, and b) Full Treatment Protocol, 1.4 x MLC the standard TFM treatment for larval Sea Lampreys. The treatments, on sections of the Mississagi River, were paired with the Aux Sables River, our control. A total of 30 radio tagged native and 202 hatchery reared Lake Sturgeon (in cages), were distributed throughout the systems. Hatchery fish ranged in size from 57 − 101 mm while the native fish ranged from 130 − 182 mm. Survival rates were not statistically different (p=0.414) between either the treatments or the control and survival was high at 93%. Survival of age-0

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hatchery and native Lake Sturgeon was high for both the Sturgeon and Full Protocol TFM treatment for larval Sea Lampreys. *Keywords: AIS control, Endangered species, Fish.*

O'DONNELL, D.M.[1], STRAIT, C.M.[1], QUARING, G.F.[1], EFFLER, S.W.[1], and LESHKEVICH, G.A.[2], [1]Upstate Freshwater Institute, PO Box 506, Syracuse, NY, 13214; [2]Great Lakes Environmental Research Laboratory, 4840 S. State Rd, Ann Arbor, MI, 48108. **Optics Surveys of Lake Ontario: Optical Characterization and Pursuit of Closure with *In Situ* Instrumentation.**

In situ measurements of inherent and apparent optical properties were made over the 2007-2009 period at mid-lake and near-shore sites in Lake Ontario to advance the characterization of the underwater and emergent light fields of these waters and to support related IOP-based model development and testing. Measurements were made using a combined profiling package of ac-s and BB9 meters (WETLabs®). 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. Spatial and temporal patterns of optical characteristics are presented and relate drivers are considered. 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: Lake Ontario, Optics, Remote sensing.*

OLYNYK, A.J., HANN, B.J., and DAVOREN, G.K., University of Manitoba - Department of Biological Sciences, 121 Machray Hall, Winnipeg, MB, R3T 2N2. **Spatial Variation In Summer Diet of Invasive Rainbow Smelt (*Osmerus mordax*) in Lake Winnipeg.**

The dietary selectivity of an invasive population of zooplanktivorous rainbow smelt (*Osmerus mordax*) was studied along a transect of 10 stations in the North Basin of Lake Winnipeg. Densities, proportions and body lengths of available zooplankton were quantified for four prey groups: copepods, *Daphnia* spp., *Eubosmina* sp. and *Bosmina* sp. Gut contents of rainbow smelt in two size classes (<120 mm and >120 mm total length) were analyzed to determine dietary proportions of zooplankton prey. Smaller smelt (<120 mm TL) displayed electivity for *Daphnia* spp. and against copepods and *Bosmina* sp. Larger smelt (>120 mm TL) showed consistently positive electivity for *Daphnia* spp. and negative electivity for all other prey groups. Rainbow smelt and zooplankton densities increased northwards along the sampling transect, paralleled by decreasing overlap between proportions of prey groups available and in gut contents. Energetic quality of prey was assessed on the basis of mean body size, escape ability and caloric content. The results of this study suggest that a gradient of smelt foraging strategy may be present in the North Basin of Lake Winnipeg, with a selective strategy in the higher water clarity of the northern section shifting towards a generalist strategy in the more turbid south. *Keywords: Lake Winnipeg, Invasive species, Trophic level.*

ONI, S.K.[1], FUTTER, M.N.[2], DILLON, P.J.[3], and MOLOT, L.A.[4], [1]Environmental and Life Sciences Graduate Programme, Trent University, Peterborough, ON, K9J 7B8, Canada; [2]Department of Aquatic Sciences and Assessment, Swedish University of Agricultural Sciences, Uppsala, Sweden; [3]Environmental and Resource Studies, Trent University, Peterborough, ON, K9J 7B8, Canada; [4]Faculty of Environmental Studiesulty of Environmental Studies, York university, Toronto, ON, M3J 1P3, Canada.
Seasonal variations and hydrologic controls of dissolved organic carbon concentrations and fluxes in Lake Simcoe watershed.

Hydrology is important in controlling surface water dissolved organic carbon DOC flow between terrestrial and surface water systems. Changing climatic conditions will impact the hydrologic cycle including the timing of runoff, and may, as a result, induce seasonality in DOC. These seasonal changes will modulate trace metal contaminant and nutrient dynamics. Lake Simcoe is the largest (722 km2) hard water lake in southern Ontario, Canada. Its watershed (3621 km2) is under increasing pressure from human development that results in frequent land use changes. Here we evaluate the impact of watershed changes on seasonal dynamic of DOC in Lake Simcoe over the decadal time scale using historical and current information. Understanding the seasonal nature of the hydrologic connectivity that mediates DOC production and transport into the lake from its catchment will lead into improved watershed management methods. A modelling approach that incorporates both the landscape and hydrologic controls on DOC at both the spatial and temporal scales is required to design effective mitigation strategies to combat the effects of future changing climate and land use. *Keywords: Lake Simcoe, Biogeochemistry, Dissolved organic matter, Water quality, Carbon cycle, Runoff.*

OSANTOWSKI, E.S.[1], MAY, J.C.[2], WARREN, G.J.[1], ADAMS, J.M.[3], and HORAVATIN, P.J.[1], [1]77 West Jackson Boulevard, G-17J, USEPA GLNPO/ Monitoring Indicators and Reporting Branch, Chicago, IL, 60604; [2]77 West Jackson Boulevard, G-17J, USEPA GLNPO/ Contractor, Chicago, IL, 60604; [3]77 West Jackson Boulevard, G-17J, USEPA GLNPO/Indiana-Illinois Seagrant, Chicago, IL, 60604.
U.S. EPA Great Lakes National Program Office Nearshore Monitoring Program using the TRIAXUS Towed 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 open waters and nearshore waters as shallow as 20m to provide spatial information of nearshore water quality and habitat characteristics. This state of the art towed instrument platform provides real-time multiparameter profiled 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, operational parameters, initial results of the open water Spring and Summer 2009 tows in each of the five Great Lakes, and the results of a 750 km nearshore tow of the Lake Michigan shoreline in October 2009. *Keywords: Monitoring, Lake Michigan, Coasts.*

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OVEISY, A.[1], BOEGMAN, L.[2], and IMBERGER, J.[3], [1]Department of Civil Engineering,, Queen's University, Kingston, ON, Canada; [2]Department of Civil Engineering,, Queen's University, Kingston, ON, Canada; [3]Centre for Water Research, University of Western Australia, Crawley, WA, AUSTRALIA. **Simulation of Ice Formation on Lake Ontario.**

Three-dimensional Reynolds averaged hydrodynamic lake models are commonly applied to the great lakes for engineering and managements studies. Until recently these models were not capable of simulating ice cover. During winter, if the cold weather persists long enough, layers of blue ice, white ice and snow will usually form on the surface of a lake. When water freezes blue ice forms and snow accumulates on the blue ice surface; if the weight of snow exceeds the buoyancy of the ice, then white ice forms from flooded snow. In this study, the governing equation of heat conduction among the three layers (white ice, blue ice and snow), air and the water is solved for the formation of ice cover. The heat transfer algorithm is coupled with the three-dimensional lake circulation model, ELCOM (Estuary and Lake Computer Model), to allow simulation of hydrodynamics and the thermal structure beneath the ice during winter. This algorithm is applied independently in each grid cell within the simulation domain, allowing for spatially variable ice formation. To validate the model, the formation of ice cover on Lake Ontario was investigated. The simulation domain was forced by two metrological stations at Kingston and Hamilton during 2006-2007. The simulated ice thickness was favorable in agreement with observations. *Keywords: Ice, Hydrodynamic model, Lake Ontario.*

PADILLA, D.K.[1], BOLTOVSKOY, D.[2], BURLAKOVA, L.[3], KARATAYEV, A.[4], MINCHIN, D.[5], and OLENIN, S.[6], [1]Department of Ecology and Evolution, Stony Brook University, Stony Brook, NY, 11794-5245; [2]Department of Biological Sciences, School of Exact and Natural Sciences, University of Buenos Aires, Buenos Aires, C1428EHA 1428, Argentina; [3]Great Lakes Center, Buffalo State College, and SUNY Research Foundation, Buffalo, NY, 14222; [4]Great Lakes Center, Buffalo State College, Buffalo, NY, 14222; [5]Marine Organism Investigations, Marina Village, Ballina, Killaloe, Co Clare, Ireland; [6]Klaipeda University, Klaipeda, Lithuania. **Can We Predict The Characteristics Of Successful Aquatic Invertebrate Invaders?**

Our ability to identify characteristics of species most likely to become important invaders will facilitate the prevention of introduction and control of non-native species that have the greatest potential to be introduced and become invasive. Determining factors and characteristics of the most successful invaders will allow targeting of limited resources at prevention of the introduction and spread of those species most likely to invade as well as cause ecological and economic damage. We examined 95 species of aquatic macroinvertebrates and considered a range of characters that have been considered by others to be important factors influencing the ability of species to be good invaders including physiological, ecological and life history characters. We tested whether there were particular characteristics shared by the most successful invaders. We found that there was no single signature of a successful invader, but that there appear to be multiple solutions to characteristics that make species important invaders in aquatic habitats. *Keywords: Macroinvertebrates, Invasive species, Exotic species.*

PALONEN, K.E.[1], DE SOLLA, S.R.[1], and STRUGER, J.[2], [1]Wildlife and Landscape Science Directorate, Environment Canada, Burlington, ON, L7R 4A6; [2]Water Science and Technology Directorate, Environment Canada, Burlington, ON, L7R 4A6. **Phenology of amphibian breeding in relation to pesticide exposure in Ontario.**

Amphibians often are exposed to pesticides while breeding in agricultural landscapes, and the timing of breeding may affect their exposure. The phenology of amphibian lifestage (egg, tadpole, metamorph, adult) varies among frog species, as does their behaviours (calling, breeding, post-breeding). Our objective was to identify the relative exposure to pesticides for each lifestage and behaviour. Using frog calling intensities, time to hatch, and time to metamorphosis for eight frog species across Ontario, we estimated the lifestage and behavioural phenologies. Data from Environment Canada's Pesticide Science Fund initiative in Ontario were used to quantify temporal changes in concentrations of pesticides in surface waters. For American toads, leopard frogs and spring peepers, the pesticide concentrations generally increased throughout their three life stages, whereas for bullfrogs and green frogs exposure was highest during the egg stage. Generally the concentrations peaked post breeding for early breeders and during breeding for late breeders, and thus pesticide residues were highest during the tadpole or metaphorph stage for late breeders. Data relating pesticide exposure with amphibian lifestage and breeding behaviour is important for assessing risk, and for designing appropriate exposure regimes for toxicological studies. *Keywords: Amphibians, Pesticides, Monitoring.*

PANCHENKO, M.V.[1], DOMYSHEVA, V.M.[2], PESTUNOV, D.A.[1], and SAKIRKO, M.V.[2], [1]1, Academicheskii Ave, Tomsk, TB, 634055, Russia; [2]Ulan-Batorskay 3, Irkutsk, IB, 664033, Russia. **CO2 fluxes in the atmosphere – water system during the free-of-ice water period in littoral zone of lake Baikal.**

In January Baikal is covered with ice, the thickness of which reaches its maximum in the beginning of April. The ice is broken usually in the end of April - the beginning of May. Investigations are carried out since 2004 in each hydrological season. From winter to summer, as the lake is heated, and quantity and composition of water biota are changed, increase of the amplitude of diurnal variations of the content of carbon dioxide in the water and in the atmosphere. The daily mean budget of carbon dioxide flux changes correspondingly. Weak sink of CO2 from the atmosphere is observed in May and June (10 mg m2day-1). Sink to the water increases to July (50 mg m2day-1) and reaches its maximum values in the second half of August (100 mg m2day-1). The inverse process is observed in autumn, the flux direction changes sign in the period just before freezing-over, and emission of CO2 into the atmosphere is observed in December (100 mg m2day-1). Summarizing the data of observations of the last 6 years, one can conclude that littoral zone of lake Baikal during the period of free of ice water is the sink of atmospheric CO2. *Keywords: Atmosphere-lake interaction, Carbon cycle, Global warming.*

PANDIT, S.N.[1], ZHAO, Y.[2], and CIBOROWSKI, J.[1], [1]University of Windsor, Department of Biological Sciences, 401 Sunset Avenue, Windsor, On, N9B3P4; [2]Aquatic Research and Development Section, Ontario Ministry of Natural Resources, 320 Milo Road, ON, N0P2P0;

[3]University of Windsor, Department of Biological Sciences, 401 Sunset Avenue, Windsor, ON, N9B3P4. **Spatial and temporal distribution of Walleye (Sander vitreum) in Lake Erie.**

Walleye is one of the most sought after species in the lower Great Lakes. Understanding the patterns of its spatial and temporal distribution has important implications for agencies' ability to manage the associated recreational and commercial walleye fisheries. We integrated gill net catch records collected over last 20 years by the Lake Erie Partnership Index Fishing Project to determine how well walleye distribution and suitable habitat could be predicted from concurrently collected measurements of depth, dissolved oxygen concentration, Secchi depth, temperature and substrate type. Significant amounts of variation in site-specific walleye density were associated with temperature and Secchi depth. *Keywords: Fish populations, Distribution patterns, Habitats.*

PANEK, S.E. and BRIDGEMAN, T.B., Lake Erie Center 6200 Bayshore Road, Oregon, OH, 43618. **The Distribution of *Lyngbya wollei* in Western Lake Erie.**

Lyngbya wollei is an invasive cyanobacterium which appeared in Maumee Bay and western Lake Erie in 2006. *L. wollei* forms dense benthic and floating mats which can negatively impact aquatic life and recreational water use. While prevalent in the southeastern United States, little is known about the distribution, abundance, and effects of *L. wollei* in western Lake Erie. The objective of this study was to record the temporal and spatial distribution of *L. wollei* in the western basin and examine relationships between *L. wollei* distribution and environmental factors. Surveys were conducted between June-September 2009 over an area of approximately 210 km^2. Benthic samples were georeferenced to create a map of *L. wollei* distribution. In addition to *L. wollei* samples, data were collected on substrate type, water chemistry, light attenuation, temperature, and depth. Results indicate widespread distribution of *L. wollei* in the western basin with the most abundant distribution found between depths of 2-4m. *L. wollei* was able to grow at low light levels. *Dreissena polymorpha* (zebra mussel) shells were the frequent substrate where *L. wollei* was present. *L. wollei* biomass was lowest in early summer and increased over the summer. *Keywords: Harmful algal blooms, Distribution patterns, Lake Erie.*

PANGLE, K.[1], TYSON, J.[2], SHAW, S.[1], LESHKEVICH, G.[3], GIULIANO, A.[3], FRIEDBERG, S.[1], BLAKE, S.[1], and LUDSIN, S.[1], [1]The Ohio State University, Columbus, OH; [2]Ohio Division of Wildlife, Sandusky, OH; [3]Great Lakes Environmental Research Laboratory (NOAA), Ann Arbor, MI. **The dynamics of river plumes and yellow perch recruitment in western Lake Erie: Are they related?**

The Maumee River plume is a dominant feature of western Lake Erie during spring and may benefit fish recruitment by providing pre-recruits a refuge from predators. To test this hypothesis, we developed a novel approach to characterizing plume size, using remotely-sensed data (satellite imagery) during 2003-2009 and then related plume size to observed success of larval yellow perch (*Perca flavescens*). Specifically, we generated daily, basin-wide maps of water clarity by developing predictive relationships between atmospherically-corrected spectral values and observed Secchi disk transparency. With these maps, we quantified the areal extent of

the Maumee River plume on a daily basis and created an annual index of plume size during the larval production period (April-May). We found that plume size varied strongly across years, being dependent on Maumee River discharge and sediment loading. Plume size was strongly correlated with an index of yellow perch juvenile recruitment ($R^2 = 0.98$), with the number of fish surviving to the new year class increasing exponentially as plume size increased. These results indicate the important role of external physical forces to Lake Erie ecosystem dynamics and provide an example of how changes in sediment loading through watershed management could influence Lake Erie fishes. *Keywords: Watersheds, Remote sensing, Yellow perch.*

PARKER, B.R. and DONALD, D.B., Environment Canada, 123 Main Steet, Winnipeg, MB, R3C 4W2. **Nutrient Loading to Lake Winnipeg via the Red River at Emerson.**

Lake Winnipeg is undergoing eutrophication in part due to increased loading of nutrients from the Red River. Spring runoff, defined herein as the period March 15 through May 31, may contribute a substantial portion of the annual nutrient load. Loading of phosphorus at Emerson was linearly correlated with flow, varying 26 fold between the highest and lowest runoff years between 1990 and 2009. In contrast, nitrogen loading varied more widely, by 40 fold over the same period and exhibited a non-linear correlation with flow. Consequently average N:P ratios during spring runoff varied with flow. Average N:P ratio by mass was not significantly different for the 4 lowest and highest flow years (mean 6.6) but was significantly less than years with intermediate flow (mean 10.6 by mass). Both nutrient loading and nutrient ratios vary with spring runoff. *Keywords: Nutrients, Red River, Lake Winnipeg, Runoff, Monitoring.*

PASCOE, T., MILANI, D., and GRAPENTINE, L., Environment Canada, 867 Lakeshore Rd., Burlington, ON, L7R 4A6. **An Overview of the Canadian Aquatic Biomonitoring Network (CABIN) and its Application to Sediment Assessment in the Great Lakes.**

The Canadian Aquatic Biomonitoring Network (CABIN) is an aquatic biological monitoring program using macroinvertebrates to assess freshwater ecosystems in Canada. CABIN is based on the network of networks approach, promoting collaboration to achieve consistent and comparable data and reporting. Environment Canada has produced a set of nationally-consistent benthic monitoring protocols, together with internet-based tools for storing data, assessing, distributing and reporting biological monitoring information. Launched in 2006, the program evolved from two large aquatic monitoring research initiatives in the 1990s. The Great Lakes Action Plan (GLAP) led to the development of nearshore sediment monitoring protocols, while the Fraser River Action Plan (FRAP) focused on wadeable streams. This talk will provide an overview of the CABIN program as a whole, identify key goals, and discuss future trends for CABIN biomonitoring, including a more detailed examination of how the program is applied in the Laurentian Great Lakes. Reference conditions for nearshore sediments in Canadian sections of the Great Lakes are quantified based on samples from approximately 160 sites. The resulting data are used for assessing ecological degradation and recovery at over 400 sites in anthropogenically disturbed areas (i.e., Areas of Concern). *Keywords: Sediments, Assessments, Benthos.*

PATERSON, G.[1], DROUILLARD, K.G.[1], and BHAVSAR, S.P.[2], [1]Great Lakes Insititue for Environmental Research, University of Windsor, Windsor, ON, N9B 3P4; [2]Ontario Ministry of the Environment, Environmental Monitoring and Reporting Branch, Etobicoke, ON, M9P 3V6. **Assessing the influence of multiple stressors on persistent organic pollutant bioaccumulation by Lake Simcoe yellow perch (*Perca flavescens*).**

Lake Simcoe yellow perch (*Perca flavescens*) provide a valuable recreational fishery and also constitute an important component of the forage base for top predators in this system. In this study, we used a combination food-web toxicokinetic and yellow perch bioenergetic model to predict size and age specific bioaccumulation rates of persistent organic pollutants (POPs) such as polychlorinated biphenyls (PCBs) in Lake Simcoe yellow perch. The yellow perch model was validated using a congener specific data set that consisted of more than 50 fish from 1 to 8 years of age and ranging in size from 25 to 248 g to evaluate steady state and non-steady state kinetics in this population. Following model validation, simulations were established to evaluate the impacts of multiple stressors including inclusion of non-indigenous species in the perch diets and hypoxia to POPs bioaccumulation rates and to place this in the context of contaminant levels observed in other food web components of the system including top piscivores such as walleye and lake trout. The results indicate that multiple stressors operating in Lake Simcoe have the potential to increase the degree of pollutant biomagnification achieved by top predators in the lake. *Keywords: Multiple stressors, Bioaccumulation, Yellow perch.*

PATERSON, G.[1], HEBERT, C.E.[2], WHITTLE, D.M.[3], DROUILLARD, K.G.[1], HAFFNER, G.D.[1], and WESELOH, D.C.V.[4], [1]Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, N9B 3P4; [2]Environment Canada, National Wildlife Research Centre, Ottawa, ON, K1A 0H3; [3]Department of Fisheries and Oceans (Emeritus), Great Lakes Laboratory for Fisheries and Aquatic Sciences, Burlington, ON, L7R 4A6; [4]Environment Canada, Canadian Wildlife Service, Downsview, ON, M3H 5T4. **Ecological tracers demonstrate changes in the foraging activities of Great Lakes avian and fish top predator species.**

The pelagic forage fish communities of the Laurentian Great Lakes have undergone significant changes in species composition and abundances since the establishment of salmonid stocking programs in the 1970's. The introductions of non-indigenous zooplankton, mollusc and fish species such as the round goby (*Apollonia melanostomus*) have also dramatically altered energy flow in Great Lakes food webs. For species such as herring gulls (*Larus argentatus*) and lake trout (*Salvelinus namaycush*) that rely on pelagic prey resources, recent evidence demonstrates that these species are experiencing bioenergetic constraints due to the changing ecology of Great Lakes food webs. Using data from long term monitoring programs and a combination of stable isotope, fatty acid, and persistent organic pollutant tracers, this research demonstrates specific changes in the foraging activities of both of these top predator species. Specifically, Great Lakes lake trout and herring gulls are including prey items in their diets that are only acquired through marked changes in their natural feeding activities and at substantial energetic costs. Importantly, these costs are being manifested in the health and condition of Great Lakes top predators. *Keywords: Stable isotopes, PCBs, Bioenergetics.*

PATTERSON, K.A.[1], BLANCHFIELD, P.J.[2], and GEILING, D.[3], [1]University of Manitoba, Winnipeg, MB; [2]Fisheries and Oceans Canada, Freshwater Institute, Winnipeg, MB; [3]Fisheries and Oceans Canada, Sault Ste. Marie, ON.
Movement patterns of rainbow trout after release from open-pen aquaculture operations in Lake Huron.

Dispersal distance and survival of escaped fish from commercial aquaculture operations are important factors in determining their potential effects on the local system. This aspect has been passed over in many impact assessments, yet is important to understanding the magnitude of potential ecological concerns that may arise with an escape event. In May 2009, we tagged (Floy tag), measured (mean = 712 g) and released 1000 rainbow trout into the North Channel of Lake Huron from two fish farms; Lake Wolsey (semi-contained) and the Wabuno Channel (open). Eighty telemetry tagged fish were released at the same time from both farms. We observed varying degrees of fidelity to sites of release for each farm. Angler reporting was relied on to obtain dispersal, survival, and growth information. In total, 8.2% of floy-tagged rainbow trout released to the wild were reported by anglers. 95% of the fish released at the Lake Wolsey farm were angled within close proximity (<5 km). In contrast, 47% of fish released at the Wabuno Channel farm were captured 20-360 km away. This large-scale movement of some escaped rainbow trout within and among the Laurentian Great Lakes is greater than originally predicted. Angler harvest data compliments and broadens patterns of site fidelity and movement observed with telemetry approaches. *Keywords: Lake Huron, Fisheries, Fish behavior.*

PATURI, S.[1], BOEGMAN, L.[1], and YERUBANDI, R.[2], [1]Department of Civil Engineering, Queen's University, 58 University avenue, Kingston, ON, K7l3N6; [2]National Water Research Institute, Environment Canada, 867 Lakeshore Road,, Burlington, ON, L7R2A6.
Near –shore hydrodynamics and tracer modeling of Upper St. Lawrence River using ELCOM model.

The near-shore hydrodynamics of the upper St. Lawrence River and eastern Lake Ontario were simulated using the Estuary and Lake Computer Model (ELCOM) for the period, April – October, 2006. Model simulated water level, temperature and current velocities were compared with observations. The error in temperature was approx 2oC through the epilimnion when the thermocline deepens during summer and the current speed errors were ~5-10 cms-1 and appear, at times, to be a result of inconsistencies in flow direction as opposed to momentum transfer from the wind. ELCOM thus reasonably captured the dynamics of the flow regimes in the near-shore region. The flow was found to be predominantly wind-induced in the south-western lacustrine portion of the domain, with dominant near inertial oscillations, and hydraulically-driven in the north-eastern riverine portion. Flow reversal of the St. Lawrence River near Kingston occurred during strong easterly storm events. Passive tracers were modeled to study the transport and pathways of contaminants. The model results were applied to delineate Intake Protection Zones (IPZs) for the eight municipal drinking water intakes in the region. *Keywords: Hydrodynamics, Hydrodynamic model, Lake Ontario.*

PAVLAC, M.M.[1], SMITH, T.T.[1], THOMAS, S.P.[1], BOYER, G.L.[1], MAKAREWICZ, J.C.[2], LEWIS, T.W.[2], EDWARDS, W.J.[3], PENNUTO, C.M.[4], BASILIKO, C.P.[4], and ATKINSON, J.F.[5], [1]SUNY College of Environmental Science and Forestry, Syracuse, NY; [2]SUNY Brockport, Brockport, NY; [3]Niagara University, Lewiston, NY; [4]Buffalo State University, Buffalo, NY; [5]University at Buffalo, Buffalo, NY. **Monitoring of the Lake Ontario Nearshore Using Real-Time Fluorescence.**

As part of the Lake Ontario Nearshore Nutrient Survey (LONNS) in 2008, continuous real-time monitoring was conducted in the nearshore waters bordering New York. A ferry-box composed of commercial fluorometers was deployed to map algal distribution and water quality parameters. Three different fluorometers, including the Turner Designs Algaewatch/Cyanowatch, the Hydrolab Sonde, and the BBE Fluoroprobe, measured algal distribution as indicated by chlorophyll and phycocyanin fluorescence. Additionally, water samples were collected for in-lab pigment extraction. Fluorescence measurements from all three fluorometers will be compared to extracted pigment values to determine which instrument is the most effective for nearshore monitoring. Ferry-box data will also be used to illustrate the temporal and spatial changes in algal distribution and physical data in the nearshore throughout the sampling season. *Keywords: Monitoring, Lake Ontario, Algae.*

PEARSON, M.J., B.M. Ross & Associates Limited Consulting Engineers, 62 North Street, Goderich, ON, N7A 2T4. **"Love the tank you're with" - Huron-Kinloss Community Septic Inspections (HK-CSI).**

"Social marketing is a process that applies marketing principles and techniques to create, communicate, and deliver value in order to influence target audience behaviours that benefit society as well as the target audience." In recent years, the nearshore area of the Lake Huron shoreline has experienced nuisance algal blooms. Water quality sampling has shown higher levels of nutrients in both the lake and area watercourses. Non point source contributions from both agriculture and septic systems are contributing to the nutrient loads. The Township of Huron-Kinloss, along the Canadian shore of Lake Huron, has implemented a mandatory septic system reinspection program, using Community Based Social Marketing (CBSM) as a means to link the actions of the lakeshore residents to the quality of the lake. This case study will examine how incorporating CBSM techniques in the design and delivery of the program serves to foster sustainable behaviours and encourages voluntary participation in a mandatory program. Currently entering its fourth year, of a projected eight year inspection cycle, over 1000 systems have been inspected. This combined stewardship program and data gathering exercise will provide long term benefits towards understanding and protecting the lake resource. *Keywords: Environmental policy, Lake Huron, Environmental education.*

PENG, F.[1], EFFLER, S.W.[1], O'DONNELL, D.M.[1], QUARING, G.F.[1], and LESHKEVICH, G.A.[2], [1]Upstate Freshwater Institute, P.O. Box 506, Syracuse, NY, 13214; [2]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48108. **Temporal and Spatial Variations in Suspended Mineral Particles in Lake Ontario: Importance to Light Scattering and Remote Sensing.**

Suspended mineral particles from Lake Ontario were collected from both pelagic and near-shore sites during the spring–summer interval of 2007–2009 and characterized by an individual particle technique (IPA). IPA provided information on composition, number concentration, and size distribution of these particles, features that are important to understanding the optical patterns (e.g., light-scattering, water clarity) of the lake. IPA results supported Mie theoretical calculations of the mineral scattering and backscattering coefficients (b_m and b_{bm}) and partitioning of these two estimates into particle type (e.g., clay minerals, calcite) contributions. Wide spatial and temporal differences in these two coefficients are reported, with generally larger calcite particles dominating (e.g., >95% of scattering) over the summer months (except for the western lake sites) and finer clay minerals prevailing at other times. The estimates of mineral (back)scattering combined with those of organic particulate (back)scattering components (from application of bio-optical models based on chlorophyll concentrations) demonstrate reasonably good closure with bulk measurements of scattering and backscattering and advance our our understanding of variability of water color, the key signal for remote sensing. *Keywords: Lake Ontario, Suspended particles, Water quality, Light scattering.*

PENNUTO, C.M.[2], JANIK, C.A.[1], CUDNEY, K.[1], and CHAPMAN, S.[1], [1]Biology Department, Buffalo State College, Buffalo, NY, 14222; [2]Great Lakes Center, Buffalo State College, Buffalo, NY, 14222.
Seasonal abundance and larval drift of invasive round gobies in a Lake Erie tributary stream.

The invasive round goby occurs in every Great Lake and a large number of tributary streams. Previous work has suggested lake-dwelling and tributary mouth gobies migrated offshore during the winter months and larval gobies exhibited pelagic drift behavior. We performed seasonal electroshocking runs at sites up to 25 km inland to determine if round gobies remained in stream habitats or returned to the lake. We also performed stream drift collections to estimate downstream timing and extent of larval production. Round gobies were collected from riffle habitats at both sites sampled in October, January, and March, suggesting that winter out-migration to Lake Erie is dependent on distance from the lake. However, winter abundance values were about half of fall values. Larval gobies were captured during July and August drift net collections. We estimate between 2,500-8,000 larval gobies occur in the downstream drift per day, or 150,000 to 625,000 per 60-day reproductive season. These data indicate that tributary streams may represent a significant additional recruitment source of round gobies to the Great Lakes, in addition to the massive in-lake production that already occurs. Further research is needed to determine survivorship of drifting fish and winter activity budgets of this invasive fish in tributary streams. *Keywords: Distribution patterns, Populations, Round goby.*

PÉREZ-FUENTETAJA, A.[1], PENNUTO, C.[1], KARATAYEV, A.[1], BURLAKOVA, L.[1], CONROY, J.[2], KRAMER, J.[3], BADE, D.[4], and MATISOFF, G.[5], [1]Great Lakes Center, Buffalo State College, Buffalo, NY, 14222; [2]Aquatic Ecology Laboratory, Ohio State University, Columbus, OH, 43212; [3]National Center for Water Quality Research, Heilderberg University, Tiffin, OH, 44883; [4]Kent State University, Kent, OH; [5]Dept. of Geological Sciences, Case

Western Reserve University, Cleveland, OH, 44106. **Biological Production and Nutrient Fate in Nearshore and Offshore Lake Erie.**

We compared phosphorus (P) fate and biological production in June/July and Sept. in transects from nearshore (depths 2, 5, 10 m) to offshore (20 m) in the Eastern (Cattaragus Creek, NY) and Central (Grand River, OH) basins of Lake Erie and in the Sandusky Subbasin (west-central basin). Sediment P content was lower in the Cattaragus and Sandusky transects (4 mg/g) and higher at Grand (8 mg/g). In the benthic environment, *Cladophora* mats were present in the Cattaragus and Grand sites (8 mg/g each). The largest P content was in benthic organisms at 5 and 10 m, with *Dreissena bugensis* having the largest contribution (Cattaragus 105 mg/g, Grand 80 mg/g and Sandusky 95 mg/g). In the pelagia, zooplankton densities were higher at 10 and 20 m and differed among lake basins. Cladoceran densities were similar in early summer at the three locations (10-40 ind/L) but were markedly high in Sept. in Sandusky (bosminids 76 ind/L). Veliger densities were very high in Cattaragus and Sandusky in Sept. (2,000 ind/L) at 5 m, comprising a significant amount of the zooplankton. *Keywords: Plankton, Benthos, Phosphorus.*

PERHAR, G. and ARHONDITSIS, G.B., University of Toronto, Toronto, ON. **From the Microscopic to the Macroscopic: Incorporating Highly Unsaturated Fatty Acids into Plankton Population Models.**

Several studies emphasize the importance of highly unsaturated fatty acids (HUFAs) at the most variable yet least predictable link in aquatic food webs: the plant-animal interface. Defined as chains of 18 or more carbons (with multiple double bonds), the inability of consumers and predators to synthesize de novo these potentially growth-limiting molecules makes them a critical factor in any diet. Studies have demonstrated a wide range of fatty acid profiles in primary producers, forcing herbivorous zooplankton to differentially retain fatty acids to meet somatic requirements. Co-limitation with elemental resources may exist, and our recent modeling results suggest food webs with high biochemical quality primary producers can attain inverted biomass distributions with efficient energy transfer between trophic levels. Given the overwhelming evidence of the HUFA importance on the energy flow in aquatic food webs, there is a surprising gap in the literature of predictive frameworks accounting for their role. We introduce a HUFA-explicit modular extension that considers the role of macronutrients and biochemical molecules in the consumer's body. Designed to make existing plankton population models HUFA-explicit with minimum effort, our aim is to demonstrate the importance of subcellular processes on ecosystem-scale dynamics. *Keywords: Mathematical models, Seston food quality, Zooplankton, Fatty acids, Stoichiometry, Phytoplankton.*

PERNICA, P.[1] and WELLS, M.G.[2], [1]Department of Physics, University of Toronto, 60 St George St, Toronto, ON, M5S 1A7; [2]Department of Physical and Environmental Sciences, Univeristy of Toronto, 1265 Military Trail, Toronto, ON, M1C 1A4. **Wind Driven Mixing of the Surface Waters of Lake Opeongo, Ontario .**

The epilimnion of a lake can experience weak diurnal stratification during periods of weak winds and net heat fluxes. This weak diurnal stratification is typically a change in 1°C over

several meters, and hence is an order of magnitude smaller than the stratification within the main thermocline. However the presence of even a weak stratification can inhibit vertical mixing within the epilimnion and so influence the spatial distribution of plankton within the euphotic zone. In this talk we present a long time-series of the thermal stratification within the surface waters of Lake Opeongo, Ontario. Typically during day-time there is a weak diurnal stratification within the epilimnion, however for strong winds we observe frequent temperature inversions. These overturns create a momentarily unstable temperature profile and can be used to indicate the presence of turbulent mixing. The temperature profile of the epilimnion was recorded in Lake Opeongo from May 2009 to September 2009. Five fast response thermistors with an accuracy of ±0.002°C, recording every 4 seconds were placed from 1 to 6 meters below the surface. We will present a relationship between wind speed, thermal stratification and the frequency of overturns, and discuss the implications to the spatial distribution of plankton. *Keywords: Water currents.*

PERROUD, M., Battelle, Building D, 7, rte de Drize, Carouge, GE, 1227, Switzerland. **Impacts of a 2 X CO2 global climate change on the thermal structure of the deep Swiss Lake Geneva.**

Changes in the thermal structure of Lake Geneva in a future warmer climate resulting from enhanced atmospheric concentrations of greenhouse gases (2 x CO2) is investigated by interfacing the one-dimensional k-ε lake model SIMSTRAT with the single column atmospheric model FIZC. Compared to former one-way experiments, the coupling allows strong feedbacks between the lake surface and the atmosphere and produces variations in atmospheric moisture and cloud cover that further modify the downward solar and infrared radiation fluxes. In a "control" 1 x CO2 climate experiment, the coupled FIZC-SIMSTRAT model has demonstrated genuine skills in reproducing epilimnic and hypolimnic temperatures. Doubling of CO2 concentration induces an atmospheric warming that impacts on the lake's thermal structure, where stratification starts earlier, the stability of the water column increases, the stratification period increases by 3 weeks, and the decay of thermocline is delayed in autumn. Epilimnic temperatures are seen to increase in the range of 2.60°C to 4.20°C whereas that of the hypolimnion is of 2.20°C. As climate changes, the surface energy budget components are mainly modified due to a reduction of the cloud cover in summer and a larger water vapour deficit at the air-water interface that induces a cooling effect in the lake. *Keywords: Climate change, Atmosphere-lake interaction, Air-water interfaces.*

PERSOON, C. and HORNBUCKLE, K.C., The University of Iowa Dept of Civil and Environmental Engineering, 4105 Seamans Center for Engineering, Iowa City, IA, 52242. **Consistent Spatial Distribution of Atmospheric PCBs 'hot spots' Over Time in Intra-City Environments.**

Identification of atmospheric PCB 'hot spots' has been done using passive samplers at 35 spots throughout metro Chicago in order to determine intra-city spatial distribution and variation in PCB concentrations. By using spatial data collected with passive samplers from 2007-2009, we can now begin to understand spatial-temporal trends in intra-city PCB concentrations. This

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study hypothesizes that atmospheric PCB 'hot spots' are consistent over time in an intra-city environment, and PCB concentrations can be contributed to spatially localized sources within Chicago. Using spatial and temporal autocorrelation, coupled with non-parametric statistical analysis ranking, preliminary results suggest that intra-city PCB concentrations in Chicago are spatially distributed consistently over time and that PCB concentrations are both declining and accumulating throughout Chicago depending on the sites spatial distribution and the localized source. *Keywords: Atmospheric circulation, Spatial distribution, PCBs.*

PETERS, K.A.[1], DZIEKAN, D.R.[1], PEACOR, S.D.[1], FRANCEOUR, S.N.[2], DYBLE BRESSIE, J.[3], and STOW, C.A.[4], [1]Michigan State University, 13 Natural Resources, East Lansing, MI, 48824; [2]316 Mark Jefferson, Eastern Michigan University, Ypsilanti, MI, 48197; [3]NOAA, Northwest Fisheries Science Center, 2725 Montlake Blvd E, Seattle, WA, 98112; [4]NOAA Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108. **Spatial and temporal analysis of nutrient vs. light limitation of benthic algae in Saginaw Bay, Lake Huron.**

Excessive algal growth has plagued Saginaw Bay, Lake Huron for decades. While reductions in nutrient inputs resulted in significant ecosystem improvements, benthic algal growth, and the resulting decaying benthic algal detritus ("muck"), has persisted. Light and nutrients are likely limiting factors of benthic algae in Saginaw Bay, but the system is complex due to the impacts of multiple stressors including a) fluctuating water levels, b) dreissenids, which have increased nutrients and light to the benthos, and c) anthropogenic nutrient loading. To investigate this problem, we collected benthic algal samples along depth, light, and nutrient gradients from June – August 2009 throughout the southwest portion of Saginaw Bay. We used pulse-amplitude-modulated fluorometry to assess the photosynthetic health of the samples and measured internal phosphorus, carbon, and nitrogen ratios to understand growth conditions. Endogenous phosphatase detection was used to determine community phosphorus limitation. The highest algal density was observed at an intermediate distance from the Saginaw River primarily at depths of 2-4 meters. We will discuss the interacting impacts of light, nutrients, and wave stress in determining the spatial variability in the regions of highest growth as well as the implications this has for managing this system. *Keywords: Benthos, Nuisance algae, Nutrients, Multiple stressor, Management, Beach fouling.*

PETRIE, S.A., Long Point Waterfowl, P.O. Box 160, Port Rowan, ON, N0E 1M0. **Waterfowl Use of the Great Lakes: Future Challenges and Opportunities.**

The Great Lakes system contains 20% of the world's fresh water, sustains an economy for approximately 30 million people, and supports millions of waterfowl throughout their annual cycle. The Great Lakes watershed supports breeding and both spring and fall migrating waterfowl, with estimated peak populations of 1.3 million pairs, 7 million, and 12.8 million respectively. A large and growing overwintering population also uses the area. I will highlight the current state of the landscape in relation to supporting the annual life cycle needs of waterfowl. I will briefly summarize breeding, wintering and spring waterfowl use of the Great Lakes watershed and summarize the state of our knowledge during each segment of the annual

cycle. Information regarding current challenges to management for waterfowl in the Great Lakes watershed will be discussed: invasive species, expanding human populations, continued loss and degradation of habitat, the effects of climate change, and wind farm developments. What the future holds for Great Lakes waterfowl and their habitats will be discussed. *Keywords: Avian ecology, Waterfowl, Invasive species, Wetlands, Mollusks.*

PIERCE, L.[1], CRAWFORD, E.[2], WILLEY, J.[2], and STEPIEN, C.A.[1], [1]Lake Erie Center and Dept. Environmental Sci., University of Toledo, Toledo, OH, 43616; [2]George Isaac Cancer Research Center, University of Toledo, Toledo, OH, 43614. **Viral Hemorrhagic Septicemia (VHS) Immersion Challenge in Juvenile Muskellunge Using StaRT PCR: A Quantification Study.**

A unique and especially virulent strain of fish viral hemorrhagic septicemia (VHS; IVb) outbroke in 2005 in the Great Lakes and subsequent years, killing several economically and ecologically important fishes. Despite efforts to reduce detection time with DNA diagnostics, cell culture - which is a weeks long laborious process - is the only currently approved method to detect VHS. Our laboratories developed and tested a new standardized reverse transcriptase polymerase chain reaction (StaRT-PCR) assay to detect and quantify VHS strains with rapid detection time, lower detection threshold, and intrinsic quality control via a standardized mixture of internal standards.We partnered with Drs. Faisal and Kim of Michigan State University to conduct an immersion challenge experiment using four doses of VHSv-IVb (1-100,000 plaque forming units/ml) in duplicate tests of 45 juvenile muskellunge. Kidney and spleen tissues were removed from two fish per tank at time points for comparative testing by MSU with cell culture and plaque assay/qRT-PCR for viral quantification versus our StaRT-PCR test results. Our test is projected to benefit aquaculture, hatchery, and baitfish facilities and Great Lakes fishery managers in accurately detecting the presence of the virus within hours. *Keywords: Genetics, VHS, Invasive species, Fish diseases.*

PIGGOTT, A.R., Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Groundwater Discharge to Surface Water in Southern Ontario and the Great Lakes Basin.**

Groundwater is an important component of the hydrologic cycle and water resources of southern Ontario and the Great Lakes basin. Groundwater is widely used as a water supply, particularly in rural areas, and its discharge to wetlands, lakes, and rivers maintains aquatic habitat and in-stream conditions, particularly during periods of otherwise low flow. Groundwater discharge to surface water is the endpoint of the process of groundwater recharge, flow, and discharge. Estimates of this discharge can be interpreted using geological data in a consistent manner across broad regional scales. For example, it is estimated that roughly 50 percent of streamflow in southern Ontario is due to groundwater discharge where this fraction varies from less than 20 percent in areas with fine textured geological materials such as clay to greater than 70 percent in areas with coarse textured materials such as sand and gravel. Research addressing issues such as the dynamics of groundwater discharge, impacts of land and water use, and implications of climate variability and change is required to complete this initial regional scale

assessment. *Keywords: Great Lakes basin, Groundwater, Hydrologic cycle, Streamflow, Watersheds.*

PILGRIM, E.M.[1], SCHAROLD, J.V.[2], DARLING, J.A.[1], and KELLY, J.R.[2], [1]Ecological Exposure Research Division, U.S. EPA, 26 Martin Luther King Dr., Cincinnati, OH, 45268; [2]Mid-Continent Ecology Division, U.S. EPA, 6201 Congdon Blvd., Duluth, MN, 55804.
 Genetic diversity of Diporeia in the Great Lakes: comparison of Lake Superior to the other Great Lakes.

Abundances of Diporeia have dropped drastically in the Great Lakes, except in Lake Superior where data suggest that population counts actually have risen. Various ecological, environmental, or geographic hypotheses have been proposed to explain the greater abundance of Lake Superior Diporeia. None of these hypotheses, however, have included the possibility of multiple distinct evolutionary lineages of Diporeia in the Great Lakes. Using mitochondrial DNA (cytochrome oxidase I) sequence data, we compared populations of Diporeia from Lakes Huron, Michigan, Ontario, and Superior. Analyses of this sequence data show Lake Superior Diporeia are a distinct evolutionary lineage that likely diverged over 100,000 years ago from Diporeia of the other Great Lakes. Although these results alone likely are not sufficient to explain the disparity in Diporeia abundance between Lake Superior and the other lakes, the presence of distinct evolutionary lineages of Diporeia within the Great Lakes should be addressed in subsequent investigations of the different population densities of this amphipod. *Keywords: Genetics, Amphipods, Diporeia.*

PINEL-ALLOUL, B., GRIL, Département sciences biologiques, Université de Montréal, C.P. 6128, Succ. Centre ville, Montréal, Québec, QC, H3C 3J7, Canada.
 The Role of Wind in the Generation of Multiscale Patterns of Plankton Heterogeneity: Implications for Ecosystem Function.

THE ROLE OF WIND IN THE GENERATION OF MULTISCALE PATTERNS OF PLANKTON HETEROGENEITY: IMPLICATIONS FOR ECOSYSTEM FUNCTION Wind-induced circulation governs water temperature and stability and the formation of water masses in freshwater systems. Environmental heterogeneity due to vertical and horizontal structuring of lakes and rivers is reflected in the distribution of plankton food web components (bacteria, phytoplankton, and zooplankton). Wind physical forcing constitutes the first step of a hierarchy of abiotic (temperature gradient, nutrient fluxes) and biotic (microbial biological coupling) processes which are the proximal forces driving plankton patchiness. However, the relative importance of physical and biological processes for driving plankton food web distribution varies with scale. We present a review on the relative role of wind in structuring plankton patchiness with a multiscale perspective. The focus will be on timescales over which physical drivers like wind contribute to the onset and the persistence of patches both vertically and horizontally. The importance of the application of new and advanced technology to assess physical forcing of plankton patchiness at the same time and space scales is also discussed. *Keywords: Lake model, Plankton, Water currents.*

PORTISS, R., 5 Shoreham Drive, Downsview, ON, M3N1S4. **Environmental Monitoring in Support of Aquatic Habitat Toronto/Fish Communities of the Toronto Waterfront.**

Baseline environmental monitoring data has been collected and assembled in order to provide agency partners; Fisheries and Oceans Canada, Ontario Ministry of Natural Resources, Toronto Region Conservation, City of Toronto, with pre-construction environmental data for major in water works associated with the Toronto Waterfront Redevelopment projects being carried out by WATERFRONTToronto. This information can be used to provide informed decisions and to track and evaluate the design features and structures that are part of the construction projects. This baseline data can be compared to the ongoing monitoring program and is used to evaluate and add insight into the designs that are being recommended by the Aquatic Habitat Toronto as outlined in the Toronto Waterfront Aquatic Habitat Restoration Strategy. This presentation can also provide an overview of the current state of fish communities on the Toronto Waterfront as collected by electrofishing methods and show trends that have been observed over the 16 year study period. *Keywords: Habitats, Fisheries, Monitoring.*

POSTE, A.E.[1], HECKY, R.E.[2], and GUILDFORD, S.J.[2], [1]University of Waterloo, 200 University Ave. W., Waterloo, ON, N2L 3G1; [2]University of Minnesota-Duluth, 2205 East Fifth Street, Duluth, MN, 55812. **Seasonal Dynamics and Bioaccumulation of Microcystin in Ugandan Lakes.**

Few studies have quantified microcystin (MC) in East African lakes, despite the fact that these lakes are a critical source of both water and food for the human and animal populations that rely on them. Water and fish samples were collected monthly from September 2008 to February 2009 from several Ugandan lakes, including Lakes Edward, George, Mburo, Saka, and two embayments of Lake Victoria (Murchison Bay and Napoleon Gulf). Water samples were analyzed for chlorophyll and nutrient concentrations, and MC was measured using ELISA. MC concentrations in water regularly exceeded the WHO drinking water guideline of 1.0 μg/L. Mean concentrations were highest in Lake Saka (27 μg/L), followed by Lake George (8.5 μg/L), Murchison Bay (7.4 μg/L), Lake Edward (2.9 μg/L), Lake Mburo (2.5 μg/L), and Napoleon Gulf (1.8 μg/L). The WHO TDI for MC is 0.04 μg/kg/day. For a 60 kg person eating 100 g fish, 33% of the fish collected from Lake Saka would exceed this threshold, while 24% from Murchison Bay, 21% from Napoleon Gulf, 10% from Lake Mburo, 6% from Lake George, and 2% from Lake Edward would also exceed this threshold. This study reveals the potential for detrimental health effects on those who rely on these lakes for water and food, and indicates that fish consumption can be an important route of MC exposure. *Keywords: Africa, Microcystin, Bioaccumulation, Harmful algal blooms.*

POULOPOULOS, J. and CAMPBELL, L.M., Department of Biology & School of Environmental Studies, Queen's University, Kingston, ON, K7L3N6. **Stable Isotope Analyses Reveal Structural Changes in Lake Simcoe Fish Food Webs From 1950s, and Impacts on Hg Bioaccumulation.**

The Lake Simcoe ecosystem has been subjected to many disturbances over the last half century, including introductions of non-native species, mercury contamination, and eutrophication. One result of such disturbances was the decline of the cold water fishery since the 1950s. Yet while such impacts are broadly recognized, it is difficult to fully understand them without greater knowledge of historical trophodynamics. Many museums house large ichthyology collections that have the potential to fill this knowledge gap. We used stable isotope analyses on such collections to determine the historical food web structure, and compared this to the modern food web. While basic trophic relationships are similar in the two time periods, some species' diets have noticeably shifted, while others have not, revealing a species-specific effect of the disturbances on the food web components. Overall, there is greater overlap in stable isotope composition among species in the modern web. As part of this project, we have assessed Hg biomagnification in the modern and historical food webs, and found similarities in the patterns of biomagnification. Our results provide a new insight into the ongoing changes in the Lake Simcoe fish community. *Keywords: Stable isotopes, Food chains, Mercury.*

POULOPOULOS, J. and CAMPBELL, L.M., Department of Biology & School of Environmental Studies, Queen's University, Kingston, ON, K7L3N6. **Hg biomagnification trends in 3 large lakes after 80 years of food web changes.**

Mercury (Hg) is a neurotoxic chemical of global concern, particularly in aquatic ecosystems. Systematic measurements of fish Hg concentrations that were initiated in the 1970s show that since that time, Hg has declined in many regions, including in the large North American lakes Nipigon, Simcoe, and Champlain. However, it is difficult to know whether the declines have returned concentrations to more historical levels, since almost no data on biological Hg contamination from before the 1970s exists. We used 50-80 year old ichthyology collections from museums to determine historical food web structures of our study lakes, and then measured Hg concentrations in corresponding historical and modern fish from those lakes. We found that Hg biomagnification patterns are similar today compared to the historical period under study, despite several structural changes to the food webs. This suggests the lake communities have some resilience against changes to Hg contamination. *Keywords: Food chains, Mercury, Stable isotopes.*

QUINN, J.S., Biology Department, McMaster University, 1280 Main Street West, Hamilton, ON, L8S 4K1. **Santa Saves the Day for Nesting Herring Gulls Threatened by Double-crested Cormorants.**

Double-crested cormorants have displaced nesting herring gulls nesting in Hamilton Harbour. The numbers of breeding herring gulls in the harbour have been declining, apparently due to loss of nesting habitat to encroaching cormorants. I decided to try a novel method for discouraging ground-nesting cormorants, while allowing herring gull nesting. My field assistants and I placed a 1.6 M singing dancing Santa Claus equipped with a motion detector and powered by a deep cycle 12 V battery through an inverter in the middle of the area being taken over by cormorants. Under permit, cormorant nests were removed on one to three day intervals. The battery was replaced with a fresh battery twice a week and the Santa was shifted on the island

once a week to reduce habituation. We staggered this treatment at different locations to allow statistical analysis. The Santa treatment was effective at repelling nesting cormorants and allowed nesting by herring gulls in close proximity to the Santa. Mechanical problems limiting Santa's movement led to recurrences of cormorant nesting activity nearby. This method is likely adaptable to other situations where a more bold ground nesting bird needs protection from nest-site competition from a less bold ground nesting species. *Keywords: Invasive species, Avian ecology, Biodiversity.*

RAMIN, M.[1], LABENCKI, T.[2], GUDIMOV, A.[1], STREMILOV, S.[1], BOYD, D.[2], and ARHONDITSIS, G.B.[1], [1]University of Toronto, Toronto, ON; [2]Ontario Ministry of the Environment, Toronto, ON.
Integration of Mathematical Modeling and Bayesian Inference for Setting Water Quality Criteria in Hamilton Harbour.

The credibility of the scientific methodology of mathematical models and their adequacy to form the basis of public policy decisions has frequently been challenged. We argue that the development of novel methods for assessing the uncertainty underlying model predictions should be a top priority of the modeling community. Bayesian calibration of process-based models is a methodological advancement that warrants consideration in aquatic ecosystem research and can be used to guide the water quality criteria setting process in Hamilton Harbour. In this study, we present the results of a Bayesian calibration exercise and examine the ability of the model to reproduce the average observed patterns. Several critical questions regarding the future response of the system are addressed. Our results show that the water quality goals for TP (17 µg L-1) and chlorophyll a concentrations (5-10 µg L-1) will likely be met, if the recommendation for phosphorus loading at the level of 142 kg day-1 is achieved. We also provide evidence that the anticipated structural shifts of the zooplankton community will determine the restoration rate of the Harbour. Finally, the coupling between the benthic and pelagic habitat and the importance of the allochthonous organic matter in sustaining the secondary production invite further investigation. *Keywords: Benthic–pelagic coupling, Mathematical models, Risk assessment, Water quality, Ecosystem restoration, Eutrophication.*

RANDALL, R.G., KOOPS, M.A., and MINNS, C.K., Fisheries and Ocean Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6.
Comparison of approaches for integrated management in coastal marine areas of Canada with the historical approach used in the Great Lakes (Bay of Quinte).

Approaches for ecosystem-based management in coastal marine areas, prompted by Canada's Oceans Act, are similar to and consistent with the long-standing, integrated management of the Bay of Quinte in Lake Ontario. The similarities include the identification of conservation objectives, biologically and ecologically significant species, and indicators of ecosystem health to measure cumulative effects of multiple stressors. The history of integrated management in the Bay of Quinte is examined, in retrospect, using the terminology that has been adopted for coastal marine areas in Canada. The three key conservation objectives, maintaining productivity, preserving biodiversity and protecting habitat, is common to both freshwater and marine ecosystems. We recommend that the Bay of Quinte be identified as a Great Lakes Coastal

Management Area, to continue the area-based integrated management approach, but also to demonstrate transition from a negative (degraded area) to a positive (area of high productivity and biodiversity) ecosystem focus. *Keywords: Ecosystem-based management, Ecosystem health, Bay of Quinte.*

RANDALL, R.G.[1], BROUSSEAU, C.M.[1], and HOYLE, J.A.[2], [1]Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [2]Ontario Ministry of Natural Resources, 41 Fish Hatchery Lane, Picton, ON, K0K 2T0. **Effect of macrophyte density on spatial variability in the abundance and growth of littoral fishes in bays of Prince Edward County, Lake Ontario.**

Biomass density and growth characteristics of pumpkinseed sunfish (Lepomis gibbosus), yellow perch (Perca flavescens), and other cohabiting species varied among different bays of Prince Edward County in eastern Lake Ontario. Catch rates, biomass and estimated production (where P = average biomass times P/B) was highest in the bays with abundant aquatic macrophytes. The fish density-biomass component of production was related to macrophyte cover, but the growth component (and P/B) was not. Results support the contention that changes in aquatic vegetation during recent years in the Bay of Quinte has affected the abundance and production of pumpkinseed sunfish and other cohabiting phytophilic fishes in this region of eastern Lake Ontario. *Keywords: Fish populations, Habitats, Bay of Quinte.*

RANKIN-GOUTHRO, E. and KRANTZBERG, G., McMaster University, 1280 Main St. W, Hamilton, ON, L8S 1K4. **The Lorax Can Win: Using Scenario Building to Create A New Vision and Invigorate An "Activist Agenda" for the Great Lakes St. Lawrence Basin.**

There is movement across the Great Lakes St. Lawrence Basin to create a binational vision. As promulgated by a group of Great Lakes stakeholders, the desired vision is one of sustainability intertwining the environmental, economic and social agendas. The creation of a new vision is timely. Scientists are warning this globally significant ecosystem is at a tipping point while heightened public awareness and government commitment are coalescing in a moment of ripeness creating a spark for transformational change. While this transformation is exigent, it is by no means certain. Moving the nascent vision through to adoption will require sanction from numerous orders of government and other interests that span an immense geographical and multi-jurisdictional area. Through the use of scenario building, four alternative futures open to the Great Lakes St. Lawrence Basin are explored. These futures and the ensuing discussion serve as a strategic means to inform the evolution of this new vision and underscore the urgency of action. Thus, we argue for an "activist" agenda in which all interests recognize the antecedent nature of the resource and the necessity of creating a macro and micro management regimes that integrate social, economic and environmental priorities. *Keywords: Policy making, Great lakes governance, Environmental policy, Ecosystem health.*

RATTAN, K.J.[1] and SMITH, R.E.H.[2], [1]Virginia Institute of Marine Science, Gloucester Point, VA, 23062; [2]University of Waterloo, Waterloo, ON, N2L 3G1. **Using Traditional Methods**

and Chl a Variable Fluorescence for Determining Nutrient Status in Oligotrophic and Eutrophic Systems.

Traditional methods of determining nutrient status in phytoplankton and variable fluorescence were used to evaluate the physiological response to phosphorus (P) limitation in oligotrophic to eutrophic lake systems, based on P and Chl a concentrations. Metabolic assays were used to estimate nutrient status at sites located in Lake Erie, Lake Ontario and Lake Huron. Variable fluorescence ratios (Fv/Fm) and rapid light curve (RLC) parameters were measured by Pulse Amplitude Modulated (PAM) fluorometer. Phytoplankton communities were associated with nutrient status, where nanoflagellates were prevalent in P deficient sites and cyanobacteria and diatoms were prevalent in eutrophic sites. In summer, P deficiency was strongest in the most oligotrophic site and least in the most eutrophic site. N status indicators and variable fluorescence revealed no N deficiency. P amendments showed a positive effect on Fv/Fm, and RLC parameters at P deficient sites and little or no effect on the least deficient site. N additions revealed a modest positive effect on Fv/Fm and RLC parameters in the most oligotrophic sites. Results confirmed that Fv/Fm and RLC parameters can reveal P deficiency and indicate its severity among the range of sites sampled, and provide evidence that P limitation could be driving the differences in composition. *Keywords: Phytoplankton, Phosphorus, Water quality.*

RAZAVI, N.R., CHAN, W., COLE, L., WANG, Y., and CAMPBELL, L.M., Department of Biology, Queen's University, Kingston, ON, K7L 3N6. **Characterizing the Food Web of a Chinese Reservoir to Identify Differences in Mercury Concentrations Between Wild and Farmed Fish.**

Freshwater fish are an important constituent of the Chinese diet, and the use of reservoirs for the capture and culture of fish is widespread in China. This study focused on an important reservoir in the Eastern Plains Lake Region of China, where elevated concentrations of mercury in top trophic predators such as yellow catfish (*Pelteobagrus fulvidraco*) were found. Preliminary trace element results indicate that wild and farmed fish species had markedly different concentrations. In this study, we will examine food web biomagnification trends for mercury and several elements for both wild and farmed fish. In 2008 and 2009, fish of several feeding guilds were collected from markets and from fishermen. Stable isotope results indicate distinct isotopic patterns among some fish species collected at different markets, suggesting some of the wild fish species brought in the market may not be from the reservoir, thereby providing a useful measure not only of food web structure, but also confirming the origin of wild-caught fish. Mercury and element bioaccumulation trends, as well as the importance of fish origin will be discussed. This study contributes essential risk assessment data that is presently lacking for many Chinese fish species, and helps to evaluate the importance of the residual effects of reservoir creation. *Keywords: Isotope studies, Trophic level, Fish.*

REAVIE, E.D.[1], BALCER, M.D.[2], and CANGELOSI, A.A.[3], [1]Natural Resources Research Institute, University of Minnesota Duluth, Ely, MN, 55731; [2]Lake Superior Research Institute, University of Wisconsin Superior, Superior, WI, 54880; [3]Northeast-Midwest Institute,

Washington DC, DC, 20001. **Testing Ballast Water Treatments at the Great Ships Initiative Land-based Facility: Zooplankton and Phytoplankton assessments.**

Ballast water discharge from ships is a significant source for the introduction and spread of aquatic invasive species. The Great Ships Initiative (GSI) is evaluating candidate shipboard treatment systems for their ability to prevent the introduction of freshwater nuisance species. Potential treatments are evaluated at the land-based test facility in Duluth/Superior Harbor (Lake Superior). The facility meets International Maritime Organization (IMO) guidelines and is the only system dedicated to testing ballast water treatment applications on freshwater organisms. Numbers of surviving ambient organisms in treated discharge are sampled and assessed using an array of methods. Specific GSI methods for sampling and assessing live plankton in size classes relevant to the IMO standards will be detailed. The 10-50 micron size class (largely algae and protists) is assessed using high-resolution microscopy and fluorescent-metabolic stains, and the >50 micron size class (zooplankton) is assessed using lower resolution microscopy and movement detection of organisms. Lessons learned during the methods development process, and outstanding issues still to be resolved, will be presented. GSI test findings will support the development of ship-board treatment systems that meet and surpass IMO standards for preventing species introductions. *Keywords: Invasive species, Ballast water, Phytoplankton, Viability, Zooplankton, Ships.*

REDDER, T.M., MCCULLOCH, R.D., DEPINTO, J.V., and GRUSH, J., 501 Avis Drive, Ann Arbor, MI, 48108. **Development and Application of a Fine-Scale Model to Evaluate Sediment Dynamics in Toledo Harbor and the Western Basin of Lake Erie.**

Sediment management is a significant challenge in many Great Lakes harbors, where frequent dredging maintenance of navigational systems is often required. Toledo Harbor, which provides navigational access from the western basin of Lake Erie through the lower 10 miles of the Maumee River, provides a good example of these challenges. The navigation channel in Toledo Harbor is subject to significant rates of sedimentation resulting from the combined effects of suspended sediment loading from the Maumee River and wind-wave resuspension and redistribution of bed sediments in Maumee Bay and Lake Erie. Dredging and disposal activities are conducted on an annual basis by the U.S. Corps of Engineers to maintain the channel at considerable expense. A fine-scale EFDC hydrodynamic and sediment transport model of the Maumee River/Bay and Lake Erie western basin is being developed to assist in the evaluation of the relative contribution of tributary loadings and wind-wave resuspension to the sedimentation problem. The sediment transport model is being calibrated to deposition volume estimates based on dredging surveys, along with other supporting datasets. Once calibrated, the model will be applied to evaluate the feasibility of alternative sediment disposal locations and related projects intended to enhance the quality of aquatic habitat. *Keywords: Sediment transport, Model studies, Sediment control.*

REDISKE, R.R. and O'KEEFE, J.P., Annis Water Resources Institute, 740 W. Shoreline Drive, Muskegon, MI, 49401. **Assessment of PCBs and PBDEs in Fish from Several Trophic Levels in Western Michigan Drowned River Mouth Lakes.**

Persistent Bioaccumulative Toxic Chemicals (PBTs) continue to pose a threat to human and environmental health in the Great Lakes basin. Polybrominated diphenylethers (PBDEs) are considered one of the most significant toxic chemicals in the Great Lakes ecosystem. We conducted an investigation of PBDEs in fish from multiple trophic levels in Kalamazoo Lake, Muskegon Lake, White Lake, and Pentwater Lake. Forage and predator species were collected from each location and analyzed for PBDE congeners by negative chemical ionization gas chromatography mass spectrometry and % lipids. PBDE concentrations were found to be variable across study sites and species, suggesting that a diffuse source such as atmospheric deposition is responsible for contaminant levels observed. The highest concentrations in common carp were found in Kalamazoo Lake and Pentwater Lake (218 ng/g and 62 ng/g, respectively). The highest concentrations in walleye and northern pike were found in Muskegon Lake (84 ng/g and 14 ng/g, respectively). Concentrations of PBDE in yellow perch, round goby, and largemouth bass were similar and ranged from 1-10 ng/g. PBDE #47 was the predominant congener detected in all species. *Keywords: PCBs, PBDEs, PBTs.*

REDMAN, R.A.[1], CZESNY, S.J.[1], and MACKEY, S.D.[2], [1]Illinois Natural History Survey, University of Illinois, Lake Michigan Biological Station, 400 17th Street, Zion, IL, 60099, US; [2]University of Windsor, Habitat Solutions NA, 37045 N Ganster Road, Beach Park, IL, 60087, US.
Evaluation of lake trout *Salvelinus namaycush* spawning habitat: Are southern Lake Michigan's offshore reefs attractive?

Historically, lake trout was the dominant predator throughout the Great Lakes. Following its extirpation from Lake Michigan by the mid 1950s, restoration of lake trout involved stocking efforts that began in 1965. More recently, management for sustainable, naturally reproducing lake trout stocks has become a critical objective throughout the Great Lakes. Lake trout aggregate at offshore reefs in southern Lake Michigan during the spawning season, but little information exists on egg deposition or habitat characteristics of these reefs. Sidescan sonar and underwater video was used to develop substrate maps for Julian's and Waukegan Reefs and identify potential lake trout spawning habitat. Recon and detailed sidescan surveys indicated the presence of additional, unknown bedrock substrate south of the area originally associated with Waukegan Reef. Multiple areas over Julian's and Waukegan Reefs were identified as potential lake trout spawning habitat due to the presence of coarse cobble-boulder substrates. These areas were targeted with deep-water egg traps during the 2009 spawning season, but no intact eggs or egg chorions were found at either reef. Underwater video from Waukegan Reef validated the presence of dreissenid mussels, which appeared to completely cover the surfaces of this reef complex. *Keywords: Lake Michigan, Fish habitat, Lake trout, GIS, Spawning habitat.*

REEVES, H.W.[1] and FEINSTEIN, D.T.[2], [1]USGS Michigan Water Science Center, 6520 Mercantile Way, Suite 5, Lansing, MI, 48911; [2]USGS Wisconsin Water Science Center, 3209 N. Maryland Ave., Room 338, Milwaukee, WI, 53211.
Regional Groundwater Availability in the Lake Michigan Basin.

USGS recently completed a regional groundwater flow model for the Lake Michigan Basin. The transient, 20-layer, two-million-node model incorporates multiple aquifers and pumping centers with cones of depression that extend into deep saline waters. The model simulates the exchange of water between surface-water bodies and shallow sequences of heterogeneous glacial deposits that overlie stratified, dipping bedrock of the Wisconsin Arch and Michigan Structural Basin. Model results illustrate the response of water levels, groundwater divides, and base flow to pumping. The greatest changes in these water level and groundwater divides occur in the western part of the basin around pumping centers that withdraw from the deep part of the flow system. Groundwater discharge directly to Lake Michigan is estimated to be approximately two percent of the overall regional groundwater budget. Most of the groundwater flow in the system is ultimately delivered to the lake as discharge to surface water tributary to the lake. An inset model embedded within the regional groundwater flow model illustrates potential streamflow depletion by a pumping well and potential effects of climate change. The regional and inset model results highlight the contrast between abundant water resources at the regional scale with limitations at local scales. *Keywords: Water distribution, Hydrologic budget.*

REID, S.F.[1] and VELIZ, M.A.[2], [1]Planning Department, County of Huron, 57 Napier Street, Goderich, ON, N7A 1W2; [2]Ausable Bayfield Conservation Authority, R.R. 3, 77108 Morrison Line, Exeter, ON, N0M 2G0. **Community Involvement in Water Quality Decision Making in Huron County, Ontario.**

National press coverage of polluted Lake Huron beaches, 100 km of shoreline developed for seasonal cottages and year-round homes, a county total livestock herd that outnumbers people by 10 to 1, and the recent Walkerton tragedy, set the stage for community conflict over water quality in Huron County, Ontario. Responsibilities related to surface and ground water were (and are) divided among agencies and organizations at all levels of government. The public and special interest groups within the community felt frustrated by a perceived lack of action and an even greater lack of coordination. In January 2004 the County of Huron formed a Water Protection Steering Committee comprising representatives of stakeholder groups including lakeshore residents' associations, industry associations, municipal councils, and agencies. Six years later, WSPC projects continue to attract outside agencies and funders, and also encourage behaviour change in the community. A case study - the North Bayfield Watershed Plan is linking individual actions to downstream water use. Through workshops and watershed tours over 30 projects have been completed in a 40 sq.km area since the planning process began in 2007. Watershed planning, with an emphasis on individualized environmental action plans will help enhance and protect Lake Huron. *Keywords: Public participation, Water quality, Lake Huron.*

RENNER, V.E. and EVANS, D.O., Ontario Ministry of Natural Resources, Trent University, Peterborough, ON, K9J 7B8. **The Thermal Regime of Lake Simcoe Has Been Modified by Invasion of Zebra Mussel, Dreissena polymorpha, and Climate Change.**

We evaluated the influence of zebra mussels and climate change on the thermal regime of Lake Simcoe. Atmospheric temperature data was compiled and vertical temperature profiles

from the surface to the lake bottom were obtained at bi-weekly intervals at two deep offshore sites from 1975 to 2008. Mean volume weighted temperatures were calculated for the epilimnion and the hypolimnion on each profile date and adjusted by linear interpolation to August 31 each year. We also determined the dates of ice-in and ice-out, seasonal heat content of the epilimnion and hypolimnion, and dates of onset and decay of thermal stratification. Water clarity improved after lake-wide colonization by zebra mussels in 1996. Maximum and mean epilimnetic temperatures increased by 2 to 3°C from 1975-2008. The temperature of the hypolimnion did not change. The effects of climate change are evident mainly in the spring where warmer winter and spring air temperatures have caused earlier ice-out. Increased water clarity, caused by zebra mussels, together with climate warming has resulted in warmer, deeper epilimnia. Increased heat content of the epilimnion has extended the duration of stratification and delayed fall mixing and winter ice-on. These changes have potentially important implications for physical and biological lake processes. *Keywords: Zebra mussels, Heat content, Climate change, Thermal regime, Lake Simcoe.*

RENNIE, M.D.[1], EVANS, D.O.[2], LA ROSE, J.L.[3], and ROBILLARD, M.M.[4], [1]Trent University, 2140 East Bank Drive, DNA Building (2nd Floor), Peterborough, ON, K9J 7B8; [2]Ontario Ministry of Natural Resources, 2140 East Bank Drive, DNA Building (2nd Floor), Peterborough, ON, K9J 7B8; [3]Lake Simcoe Fisheries Assessment Unit, 26465 York Road 18, Sutton West, ON, L0E 1R0; [4]Lake Simcoe Fisheries Assessment Unit, 26465 York Road 18, Sutton West, ON, L0E 1R0. **Isotopes reveal changes in the importance and identity of offshore resources to coldwater fishes in Lake Simcoe.**

The offshore ecosystem of Lake Simcoe has changed dramatically during the past 20-30 years, characterized by improvements in deep water oxygen conditions, increasing anthropogenic activities around the lake, changes in the thermal dynamics of the lake and major species invasions. We describe how these changes have affected the importance of nearshore vs. offshore resources for coldwater fishes in Lake Simcoe by examining trends in stable isotopes of carbon and nitrogen from archived fish and invertebrate tissues. Preliminary results show that consumer species (lake whitefish, lake herring, rainbow smelt) all demonstrate pointed shifts towards more nearshore resources at or just prior to the close of the last century. In contrast, predatory lake trout show a more gradual and increasing reliance on offshore resources during this same period, accompanied by a decline in trophic position. We suggest that the patterns in consumer fishes are consistent with the expectations of a nearshore shunt of resources in Lake Simcoe associated with dreissenid establishment in the mid 1990s. However, trends in lake trout may more closely reflect declines in the pelagic fish community and what appears to be an unprecedented increase in Mysis diluvania densities in the lake. *Keywords: Fish, Stable isotopes, Trophic level, Offshore, Lake Simcoe, Dreissena.*

RENNIE, M.D.[1], EBENER, M.P.[2], and WAGNER, T.[3], [1]Trent University, 2140 East Bank Drive, DNA Building (2nd Floor), Peterborough, ON, K9J 7B8; [2]Inter-Tribal Fisheries and Assessment Program, Chippewa Ottawa Resource Authority, 179 W. Three Mile Road, Sault Ste. Marie, MI, 49783; [3]U.S. Geological Survey, Pennsylvania Cooperative Fish & Wildlife Research Unit, Pennsylvania State University, 402 Forest Resources Bldg, University Park, PA,

16802. **Can migration mitigate the effects of ecosystem change? Patterns of dispersal, energy acquisition and allocation in Great Lakes lake whitefish (Coregonus clupeaformis).**

Fish can migrate in response to poor or declining home range habitat quality in order to seek out better resources. Despite dramatic changes in the benthic food web of the Laurentian Great Lakes since the colonization of dreissenid mussels, coincident changes in growth rates among benthivorous lake whitefish populations have been variable. We hypothesized that this variation could be in part mitigated by differences in migratory habits among populations, where more mobile populations have an increased probability of encountering high-quality habitats (relative to the home range). Results from four Great Lakes populations support this hypothesis; relative growth rates increased regularly with migration distance. The most mobile population showed the smallest decline in size-at-age during a period of significant ecosystem change, and had among the highest estimated consumption and activity rates. In comparison, the population with the greatest declines in size-at-age was among the least mobile, with only moderate rates of consumption and activity. The least mobile population of lake whitefish was supported by a remnant Diporeia population and has experienced only moderate growth declines. Our study provides evidence for the potential role of migration in mitigating the effects of ecosystem change on lake whitefish populations. *Keywords: Lake whitefish, Diporeia, Dreissena, Migrations, Mercury, Bioenergetics.*

VALIPOUR, R.[1], BOEGMAN, L.[1], BOUFFARD, D.[1], and YERUBANDI, R.[2], [1]Civil Engineering Department, Queen's University, Kingston, ON, K7L 3N6, Canada; [2]National Water Research Institute, Burlington, ON, L7R 4A6, Canada.
Large Scale Internal Waves in the Central Basin of Lake Erie.

Wind induced large scale waves play a crucial role in physical processes and the resultant biological activities in Lake Erie. To have a better understanding about how these basin-scale internal waves influence the oxygen distribution throughout the water column, time series data of velocity and temperature were recorded in the central basin of Lake Erie during the summer of 2008/09. We applied rotary spectra to the velocity data and spectra of available potential energy from temperature time series to show a dominant clockwise peak around 17 hour. This well known near inertial peak is due to the presence of Poincare waves during stratification periods. The present study tries to clarify the physical characteristics of the Poincare waves in the central basin of Lake Erie by calculating the cell size in which Poincare waves undulate, the wave number, the period and the shape of these waves during the stratification periods as well as the associated velocity profile throughout the water column. *Keywords: Central basin of Lake Erie, Poincare wave, stratification period, Lake Erie, Basin scale, internal waves.*

RICHARDS, R.P., Heidelberg University, 310 E. Market Street, Tiffin, OH, 44883.
 Probabilistic Analysis of Exposure to Atrazine in Northwest Ohio Rivers: Seasonal Patterns.

The National Center for Water Quality Research at Heidelberg University has monitored atrazine concentrations in the Maumee and Sandusky Rivers since 1983, and has generated

atrazine concentrations from more than 2000 samples for each river. Atrazine is widely applied in these watersheds. Atrazine is more likely to impact non-target organisms via chronic rather than acute exposure, so it is of interest to know the distributions of concentrations averaged over different periods of time, ranging from several days to ninety days. We created complete daily time series of concentrations, then processed them to determine the probability of occurrence of average concentrations as a function of the time of year. The results are plotted as a raster graph comparable to those often used in limnology. This analysis shows, for example, that significant probabilities (>0.5) of atrazine concentrations exceeding 5 µg/L are concentrated in May and June. As the length of the averaging period increases, the probability of concentrations greater than about 5 µg/L decreases, but the probabilities of lower concentrations do not. Averaging does not reduce the total exposure – the sum of the concentrations, but only changes the distribution of the concentrations, making high concentrations less frequent and low concentrations more frequent. *Keywords: Tributaries, Environmental contaminants, Atrazine.*

RICHMAN, L.[1], SOMERS, K.[1], WILLIAMS, D.[2], REINER, E.[1], and HOBSON, G.[1], [1]Ontario Ministry of Environment, 125 Resources Rd, Etobicoke, ON, M9P 3V6; [2]Environment Canada, 867 Lakeshore Rd, Burlington, ON, L7R 4A6.
MONITORING METAL AND PERSISTENT ORGANIC CONTAMINANTS THROUGH TIME USING CAGED MUSSELS (*Elliptio complanata*) and QUAGGA MUSSELS (*Dreissena bugensis*) COLLECTED FROM THE NIAGARA RIVER (1983-2009).

Historically, the Niagara River received significant discharges of persistent, bioaccumulative, toxic chemicals from outfalls and hazardous waste sites. Since 1983, the Ontario Ministry of Environment Mussel Biomonitoring Program has monitored 77 Canadian and U.S. sites for the presence of toxic chemicals using caged freshwater mussels. The Program provided information on contaminant sources between Fort Erie and Niagara-on-the-Lake (e.g. Hyde Park waste site, Gill Creek, Pettit Flume), and has been instrumental in documenting the effectiveness of remedial actions implemented in tributaries and hazardous waste sites. In 1995 and 2003, tissue contaminant concentrations were also monitored in indigenous quagga mussels at 9 locations in the River to assess anticipated changes in response to ongoing remedial efforts. Concentrations of PCBs, hexachlorobenzene, hexachlorobutadiene and octachlorostyrene in quagga mussels in 2003 were lower than those measured in 1995, consistent with reported decreases in mean annual water concentrations of these compounds. In contrast, metal concentrations were similar in both years and consistent with values reported in mussels from other industrialized areas in the Great Lakes Basin. Overall, results suggest that remedial efforts to improve water quality in the Niagara River have been successful. *Keywords: Niagara River, Environmental contaminants, Biomonitoring.*

RIGOSI, A.[1], MARCÉ, R.[2], ESCOT, C.[3], and RUEDA, F.[4], [1]Instituto del Agua, Department of Ecology, University of Granada, Calle Ramon y Cajal 4, Granada, 18003, Spain; [2]Catalan Institute for Water Research (ICRA), Scientific and Technological Parc of the University of, Girona, 17003, Spain; [3]Empresa Metropolitana de Abastecimiento y Saneamiento de Aguas de Sevilla, S.A. EMASESA, Calle Escu, Seville, 41003, Spain; [4]Departamento de Ingeniería Civil,

Universidad de Granada, Granada, Spain. **Calibration strategy for dynamic succession models including several phytoplankton groups.**

An accurate description of the relationships between physical environment and ecological conditions, and a proper representation of phytoplankton succession structure, are central topics in water quality modeling.In this work a new calibration strategy is proposed for a dynamic ecological model, that differentiates five phytoplankton groups. Sensitivity analysis and global automatic calibration algorithms are successfully applied to the deterministic, highly parameterized model to solve over parameterization and reduce time of calibration.When the level of description of phytoplankton groups was adequate to system complexity, it was possible to calibrate phytoplankton groups separately and then simulate them toghether without reducing model performance.Model results reproduced the seasonal evolution of most of the algal groups considered in simulation, when an adequate information set was included in the calibration process.Through the applied method we prove that a good representation of phytoplankton succession is feasible without simplifying model structure or limiting number of simulated phytoplankton groups. Our findings illustrate that integration of automatic calibration strategies in complex deterministic ecological models is a useful approach to improve model performance. *Keywords: Phytoplankton, Optimization algorithms, Water quality, Calibration, Model studies, Coupled models.*

RITCEY, A.L. and CAMPBELL, L., School of Environmental Studies, Queen's University, Biosciences Complex, Room 3134, Kingston, ON, K7L 3N5, Canada.
Governance Across Borders: Disparate approaches to remediation in the International Region of the St. Lawrence.

The St. Lawrence River Area of Concern (AOC) is a binational AOC under the auspices of the International Joint Commission. The AOC is an 80 km stretch of the international section of the St. Lawrence that is jurisdictionally divided between Canada and the United States. Collectively, there has been a joint goal and problem statement for the entire AOC. Independently, separate Remedial Action Plans (RAPs) have been structured and implemented in Cornwall, ON and Massena, NY. Guided by the Great Lakes Water Quality Agreement, the Cornwall RAP is completing the final stage of the program with the aim of delisting this year. This paper will explore the governance approaches undertaken by the Cornwall RAP, which has prepared them to de-list ahead of Massena. The research methods include stakeholder interview analysis, document and literature review, and observations from restoration council meetings, conferences and workshops. From these analyses, the Cornwall RAP has shown to employ an inclusive and collaborative governance model, which provides avenues for discussion, learning and consensus building among diverse stakeholders. To reinforce the binational character of the AOC, lessons from this approach should be adapted on a regional basis to support a collaborative St. Lawrence River wide effort. *Keywords: Environmental policy, Regional analysis, St. Lawrence River.*

ROBILLARD, M.M.[1], MCLAUGHLIN, R.L.[1], and MACKERETH, R.W.[2], [1]Department of Integrative Biology, University of Guelph, Guelph, ON, N1G 2W1; [2]Centre for Northern Forest

Ecosystem Research, Ontario Ministry of Natural Resources, Lakehead University, Thunder Bay, On, P7B 5E1. **A framework to guide research into complex migratory systems applied to migratory brook trout in Lake Superior.**

Migration is a complex form of behaviour that presents significant scientific and management challenges. In fishes, the migratory behaviour of many populations remains poorly characterized despite advances in tracking methods and the analysis of tracking data. Consequently, qualitative descriptors of migratory behaviours (eg. resident and migrant) are often assigned to populations or sub-populations when supporting data are lacking and adoption of these classifications can overlook the diversity of ecological mechanisms that can generate individual variation in migratory behaviour. We developed a rigorous theoretical framework to distinguish among competing hypotheses that could give rise to the apparent resident and migrant forms. We can distinguish between these hypotheses by addressing four ecological uncertainties: evidence of two forms differing in ecology, evidence of non-random mating, evidence of two versus one growth trajectory, and evidence that individuals purported to be residents complete their lifecycle in one habitat. Presented as a decision tree the framework prioritizes the order in which these uncertainties are addressed. We use Lake Superior brook trout to demonstrate how this framework has been used to guide research delineating the migratory system giving rise to the lake and stream resident forms. _Keywords: Migrations, Trout, Lake Superior._

ROBINSON, C.[1], XIN, P.[2], LI, L.[2], and CROWE, A.S.[3], [1]Civil and Environmental Engineering, The University of Western Ontario, London, ON, N6A 5B9, Canada; [2]School of Engineering, University of Queensland, Brisbane, 4066, Australia; [3]Environment Canada, Canada Centre for Inland Waters, Burlington, ON, L7R 4A6, Canada. **Effect of waves on composition of groundwater discharge and associated chemical fluxes to nearshore waters from sandy shorelines.**

While groundwater discharge to oceanic waters has received significant attention in the past decade, the groundwater pathway and its contribution to chemical loading to the Great Lakes remains poorly understood. Nevertheless much knowledge is transferrable between the oceanic and lake environments. Groundwater discharge comprises not only terrestrial groundwater but also water recirculating across the sediment-water interface. In quantifying groundwater discharge rates it is essential to identify these separate components. The mixing of the fresh and recirculating waters creates an important subsurface reaction zone in nearshore aquifers that strongly controls the fate of contaminants discharging and cycling through the nearshore sediments. The shorelines of the Great Lakes are often subject to significant wave actions. The analytical model of Longuet-Higgins is applied to quantify wave-driven recirculation showing that it may constitute a major part of the total nearshore groundwater discharge. In addition, a near-shore wave model (BEACHWIN) coupled with a saturated-unsaturated groundwater flow model (SUTRA) is applied to demonstrate the wave effects on watertable fluctuations and subsurface flow patterns. Input conditions used are based on the range of conditions at the sandy shores of the Great Lakes. _Keywords: Coastal processes, Groundwater, Waves, Beaches, Water quality, Groundwater-coastal water interactions._

ROBINSON, S.A.[1], FORBES, M.R.[1], and HEBERT, C.E.[2], [1]Carleton University, 1125 Colonel By Drive, Ottawa, ON, K1S5B6; [2]Environment Canada, National Wildlife Research Centre, Raven Road - Carleton University campus, Ottawa, ON, K1A0H3. **Parasitism, Mercury Contamination and Stable Isotopes in Cormorants.**

Contaminants and parasitism have been positively related in free-ranging birds. One proposed explanation is that contaminants reduce host immunity resulting in a greater susceptibility to parasitism. However, alternative explanations should be addressed to further inform and test hypotheses about relationships between contaminants and parasitism. We investigated whether total mercury and *Contracaecum* spp. were related in double-crested cormorants *Phalacrocorax auritus* and whether there was support for contaminants and infective stages of parasites being co-ingested. For breeding cormorants, males had 1.5 times more total mercury in breast muscle than did females and > 2 times more *Contracaecum* spp. (nematodes). Different males were responsible for the two sex biases hence separate explanations for each pattern were required. Males foraged in more pelagic areas and at a slightly lower trophic level than did females, as determined by stable C and N isotope signatures, respectively. Sex biases in parasitism but not mercury concentration could be explained by sex differences in use of foraging habitats. We found similar results in a second sample of cormorants from another lake ecosystem; therefore, we rule out the likelihood that original patterns were due to chance. *Keywords: Mercury, Parasites, Avian ecology, Cormorants.*

ROBLIN, R.J.[1], LU, Q.[1], DUCKETT, F.J.L.[1], and TAYLOR, S.R.[2], [1]Baird & Associates, 1267 Cornwall Rd, Suite 100, Oakville, ON, L6J 7T5; [2]Essex Region Conservation Authority, 360 Fairfield Ave. West, Suite 311, Essex, ON, N8M 1Y6. **Implications of Reverse Flow in the Detroit River for Source Water Protection Studies.**

There are three Canadian municipal intakes located in the Detroit River: two at the Windsor water plant and one at Amherstburg. It is well known that reverse flow occurs in the downstream reaches of the Detroit River as a result of Lake Erie surge from the east. However, less known, is that reverse flow also occurs near the upstream end of the Detroit River, causing the River to flow toward Lake St. Clair and potentially move water-borne contaminants in an upstream direction. The Intake Protection Zone (IPZ-2s) for the three intakes were delineated considering 10-year return period events. Reverse flows were found to occur along the length of the Detroit River during some of the model simulations. Quinn (1988) and Derecki and Quinn (1990) note that reverse flows may occur along the Detroit River as a result of low flows in the St. Clair River (due to ice jams) and/or during strong meteorological events (as documented during a December 15, 1987 event). As a result of the modelled reverse flows the IPZ-2s for the Windsor and Amherstburg intakes extend a considerable distance in the downstream direction as well as the upstream direction. The next phase of work involves calibrating the model to the observed 1987 reverse flow event, in order to refine the downstream extent of the IPZs for the Windsor intakes. *Keywords: Water currents, Model studies, Detroit River.*

ROBSON, M.E.[1], MELYMUK, L.E.[2], CSISZAR, S.A.[2], GILBERT, B.[3], HELM, P.A.[3], DIAMOND, M.L.[1], BACKUS, S.[4], JANTUNEN, L.M.[5], and DAGGUPATY, S.[5], [1]Department of Geography, University of Toronto,, 100 St George Street,, Toronto, ON, M5S 3G3; [2]Departmental Address Department of Chemical Engineering & Applied Chemistry, University of Toronto, 200 College Street,, Toronto,, ON, M5S 3E5; [3]Ontario Ministry of the Environment,, 125 Resources Road,, Toronto, ON, M9P 3V6; [4]Environment Canada,, 867 Lakeshore Road,, Burlington, ON, L7R 4A6; [5]Environment Canada, 4905 Dufferin Street,, Toronto, ON, M3H 5T4.
Urban Sources and Loadings of Toxics to Lake Ontario from the Greater Toronto Area.

A multimedia measurement and modeling project has been undertaken to evaluate the fate and transport of selected POPs in Toronto, Canada. This allows assessment of the relative importance of loading pathways and sources of POPs from atmospheric deposition (wet and dry), stream runoff and waste water treatment plants to nearshore Lake Ontario. The project has involved determining concentrations in a year long measurement campaign of selected POPs (PCBs, PAH, PCMs and PBDEs) in air, soil, precipitation and tributary waters in Toronto, Canada. These data are used to estimate loadings and also in a coupled multimedia-air dispersion model. This presentation will give an overview of the initial three months of this data. Results from this work show that there is a strong urban-rural gradient in concentrations of all the compounds studied, however the loading and significance of each pathway to the lake differ between the chemicals. *Keywords: Urban areas, Environmental contaminants, Pollution sources.*

ROCKWELL, D.C.[1], SCHWAB, D.J.[2], and JOSHI, S.J.[3], [1]CILER - University of Michigan, 755 Raintree Drive, Naperville, IL, 60540-6331; [2]NOAA- Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108; [3]Michigan Sea Grant Outreach Coordinator, 4840 South State Road, Ann Arbor, MI, 48108.
60 Hour Beach Water Quality Forecasting Models.

NOAA's Center of Excellence Great Lakes and Human Health is developing and testing a 60 Hour beach forecasting model. Forecast models are the next step in predictive models and use only parameters that come from the National Digital Forecast Database (NDFD) and the Great Lakes Coastal Forecast System (GLCFS) to estimate recreational water quality at beaches. These variables include rainfall, wind direction and velocity, lake currents, interpolated air temperature, surface water temperature, cloud cover, and time of sampling. The predictive model developed using deterministic model parameters will allow the NWS to provide 24/7 forecasts for beaches with forecast models. These forecasts will provide timely communications to the public via normal weather forecasts. Such forecasts of beach health and daily swimming conditions will allow the public to plan recreational trips to the beach. Using USEPA's Virtual Beach with these explanatory real time measurements, E. coli is being modeled at test-bed beaches. An initial model has an R2 factor of 38.7% and an adj. R2 factor near 35.6%. This is comparable to regional nowcast models (adj. R2 between 14-43%) but at the low end of models used to manage swimming based on beach measured parameters (adj. R2 between 38-42%). NWS alpha test beds are planned this summer at three beaches. *Keywords: E. coli, Water quality, Beach, Model testing, Public education, Bacteria.*

ROEHM, C.L. and WILSON, M., Great Lakes Center, Buffalo Stae College, SUNY, Buffalo, NY, 14222, USA.
Nutrient dynamics in coastal wetlands of Lake Ontario affected by algal blooms.

Coastal wetlands act as pollution buffers. In their absence, direct input of non-point source pollution into aquatic ecosystems is known to cause severe eutrophication. However, in regions with a long history of non-point source inputs of nutrients, coastal wetlands are supersaturated and may act as nutrient sources to nearshore lake regions. In this study we studied (field and lab) the seasonal dynamics of nutrients in a set of coastal wetlands on Lake Ontario. The results to date indicate a release of P from the sediments in the main pond at each sampling period, with increasingly high concentrations in the water column and the formation of algal blooms in July. The highest rates of denitrification were found in the most oligotrophic pond, accompanied by a rapid decrease in PO_{34-} over the bioassay time. The more eutrophic ponds experienced increasing concentration of PO_{34-} in solution. The results indicate that the oligotrophic pond is limited and, hence, still a potential sink for excess nutrients, unlike the eutrophic ponds which experienced algal bloom events during the summer. These results present large implications for coastal management, since release of P from sediments into the water is evidenced by algal blooms and potentially causing an additional P loading to nearshore environments of Lake Ontario. *Keywords: Coastal ecosystems, Ecosystems, Wetlands, Algal blooms, Nutrients, Lake Ontario.*

ROGERS, E.D.[1], HENRY, T.B.[2], TWINER, M.J.[3], GOUFFON, J.S.[4], SAYLOR, G.S.[5], and WILHELM, S.W.[6], [1]Center for Enviro. Biotechnol., Depart. Forestry, Wildlife and Fisheries, University of Tennessee, Knoxville, TN, USA; [2]Center for Environmental Biotechnology, University of Tennessee, Ecotoxicology and Stress Biology Research Center, University of Plymouth, Plymouth, Devon, UK, Knoxville and Plymouth, USA and UK; [3]Department of Natural Sciences, University of Michigan-Dearborn, Dearborn, USA; [4]Affymetrix Core Facility, University of Tennessee, Knoxville, USA; [5]Center for Environmental Biotechnology, Department of Microbiology, University of Tennessee, Knoxville, USA; [6]Department of Microbiology, University of Tennessee, Knoxville, USA.
From Zebras to Cats: Development of Transcriptional Biomarkers in Larval Zebrafish for Application to Channel Catfish Exposed to Microcystis and the Cyanotoxin Microcystin.

Microcystis blooms occur worldwide and are particularly persistent in the western basin of Lake Erie with microcystin (MC) toxin concentrations occasionally exceeding the WHO advisory level of 1 µg/L. While fish kills have been globally associated with elevated MC concentrations, sub-lethal effects are largely unknown. We exposed zebrafish (Danio rerio) larvae to purified MC-LR (0-1,000 µg/L) or lyophilized M. aeruginosa containing 4.5 µg/L MC-LR and determined effects on global gene expression. Bioinformatic analyses have identified the molecular effects of MC toxin exposure consistent with its known mechanism of action (i.e., protein phosphatase inhibition, cell signaling, regulation of cytoskeleton, ion regulation, oxidative stress). Furthermore, these analyses also identified a novel, MC-independent phenomenon involving estrogenic effects (i.e., vitellogenin genes) of the Microcystis cell lysates.

These analyses not only identified mechanisms of toxicity for MC in fish and revealed new pathways of interest for both the MC toxin and one of its producers, M. aeruginosa, but also identified genes to be used in the future as the basis towards the development of diagnostic and/or prognostic biomarkers in channel catfish (Ictalurus punctatus) exposed in vitro and in situ to these cyanobacteria species and their toxins. *Keywords: Algae, Cyanotoxin, Toxic substances, Biomarkers, Fish, Toxicology.*

ROKITNICKI-WOJCIK, D., MIDWOOD, J., CIMAROLI, K., and CHOW-FRASER, P., 1280 Main St W, Hamilton, ON, L8S 4K1. **Development of an inventory of coastal wetlands for eastern Georgian Bay, Lake Huron.**

Coastal wetlands of eastern Georgian Bay provide critical habitat for a variety of wildlife, especially spawning and nursery habitat for Great Lakes fishes. Although this unique insular landscape has been designated a World Biosphere Reserve by UNESCO and may potentially be the largest concentration of coastal wetland habitat in the Great Lakes, a complete inventory is lacking. This is impeding proper recognition of the region and management and conservation efforts. Here we outline the methodology, analyses, and applications of the McMaster Coastal Wetland Inventory (MCWI) created from a comprehensive collection of IKONOS satellite imagery from 2002-2007. We focus on the coastal zone, operationally defined as habitat within 2 km upstream of the 1:100 year floodline of the lake. Wetlands were manually delineated in a GIS as two broad habitat types; coastal marsh and upstream wetland. Within eastern coastal Georgian Bay there are 5451 distinct wetland units with an areal extent of 13753 ha, nearly 4 fold that of pre-existing inventories. The MCWI provides the most current and comprehensive inventory of coastal wetlands in eastern Georgian Bay and further validates the significance of this region as the coastal wetland hotspot of the Great Lakes. *Keywords: Coastal wetlands, Inventory, Georgian Bay, Fish habitat, GIS.*

ROSWELL, C.R.[1], HÖÖK, T.O.[1], and POTHOVEN, S.A.[2], [1]715 West State St., West Lafayette, IN, 47907; [2]1431 Beach St., Muskegon, MI, 49441. **Diet Selection and Growth of age-0 yellow perch (*Perca flavescens*) in Saginaw Bay, Lake Huron.**

Yellow perch are important economically, recreationally, and ecologically in Saginaw Bay, Lake Huron. Monitoring in recent years has indicated that production of age-0 perch in Saginaw Bay increased after the collapse of the Lake Huron alewife population, which had potentially competed with or preyed upon larval yellow perch. However, despite this increased production of young yellow perch, age-0 perch are smaller, and recruitment to the adult population has not increased. To understand the influence of early life stages on recruitment, we sampled larval and juvenile yellow perch, zooplankton, and benthic invertebrates at up to 18 sites in Saginaw Bay on a weekly basis during April-October 2009. We tracked changes in size, condition, and diet composition over time. Perch hatched in late April and early May, and were large enough to be vulnerable to capture in bottom trawls by mid-July. Most larval yellow perch consumed primarily zooplankton, while juvenile perch consumed zooplankton and benthic invertebrates. High densities of yellow perch and other benthivorous fish may contribute to

reduced growth during the juvenile stage. *Keywords: Fish diets, Early-life, Yellow perch, Fish growth, Recruitment.*

ROUSSI, C.[1], HART, B.[1], WHITE, B.[1], SHUCHMAN, R.[1], and KERFOOT, C.[2], [1]Michigan Tech Research Institute, 3600 Green Ct., ste.100, Ann Arbor, MI, 48105; [2]Michigan Tech University, 1400 Townsend, Houghton, MI, 49931. **A Ship-based Distributed Sensor Network for Lake Superior Water Quality Measurements.**

The study of Lake Superior water quality would benefit from frequent, long-term, and accurate, measurements. These requirements can be difficult or expensive to satisfy. The National Park Service operates, on a regular schedule, a ferry between Houghton, MI, and Isle Royale National Park. This vessel covers the same routes during the summer operating season, and is an ideal platform from which to make measurements. However, the measurement system was constrained in a number of ways: there must be no changes to the ship structure or systems, it must be automated, requiring no crew interactions, and the sensors must span several decks. A novel architecture was developed to meet these goals. A distributed array of sensors, including GPS location speed, direction, temperature, turbidity, chlorophyll, pH, conductivity, and a meteorological array, was deployed and tested. During the 110km passage, measurements were made every 30s (a maximum spacing of 210 m between measurements), and logged by a control computer. These data were displayed graphically to the passengers during the collection, and transmitted to MTRI for analysis via Internet when the ship docked in Houghton. Results (to be incorporated into the GLOS data management system) indicate accurate,timely,and economical measurements can be made from a ship-borne system. *Keywords: Water quality, Lake Superior, Measuring instruments.*

ROWSELL, R.D. and DEPALMA, S.G.S., Environment Canada, WS&T, 867 Lakeshore Road, PO Box 5050, Burlington, ON, L7R 4A6. **GUI Structured Quality Assurance of Shipboard Water Quality Measurements in Canadian Freshwaters.**

Environment Canada in Burlington, ON has collected water quality information in support of the Great Lakes Water Quality Agreement (GLWQA) and other research for the last 3 decades. Although strict calibration procedures are followed to ensure quality of the collected raw data, a formal method must be implemented as a systematic approach for identifying and flagging anomalies in the dataset. A graphical user interface (GUI) has been developed in Matlab® that will enable users with a solid understanding of water quality in freshwater environments to assess shipboard data from water quality profilers prior to archiving for further analyses. This quality assurance (QA) method incorporates automated checks and manual visual inspection of the data by a qualified QA officer. Based on internal calculations and user assessment, QA flags are inputted into the data files, which indicate the quality of the data and note if any necessary changes were made. Systematic QA methodology of freshwater profiles will greatly enhance the quality and reliability of water quality information collected by Environment Canada. Furthermore, implementation in GUI format will facilitate the timely correction of minor data errors in preparation of further scientific analyses. *Keywords: Graphical user interface, Great Lakes basin, Quality Assurance, Water quality.*

RUBERG, S.A.[1], BLACK, T.J.[2], BIDDANDA, B.A.[3], HAWLEY, N.[1], KENDALL, S.T.[3], PADDOCK, R.W.[4], and GREEN, R.[5], [1]Great Lakes Environmental Research Lab, 4840 South State Rd, Ann Arbor, MI, 48108, US; [2]Office of Geological Survey, 2100 West M32, Gaylord, MI, 49735, US; [3]GVSU Annis Water Resources Institute, 740 West Shoreline Dr, Muskegon, MI, 49441, US; [4]UWM Great Lakes WATER Institute, 600 East Greenfield Ave, Milwaukee, WI, 53204, US; [5]Thunder Bay National Marine Sanctuary, 500 West Fletcher St., Alpena, MI, 49707, US. **Exploration of Submerged Karst Systems in Lake Huron.**

In the northern Great Lakes region, limestone karst features such as caves and sinkholes were formed as sediments, deposited some 400 million ybp during the Devonian era, experienced erosion. Submerged karst features were discovered in northern Lake Huron at depths of 92 meters and greater during a 2001 sidescan sonar survey expedition conducted by the Thunder Bay National Marine Sanctuary (TBNMS). Additional karst features near shore have been known for some time but have received little scientific exploration. Initial explorations undertaken in September, 2003 used a CTD system and an acoustic tracking system integrated with an open frame remotely operated vehicle (ROV) to provide high-resolution depth, temperature and conductivity maps. Studies during the 2005-2009 sampling seasons used aerial photography, ship-deployed CTD profiling of the water column, physico-chemical mapping, time series measurements, remotely operated vehicle (ROV) surveys, diver observations and bathymetric mapping to obtain a better understanding of sinkhole features and to observe physical interactions of the systems' groundwater with Lake Huron. Findings to date have led to a better understanding of distinct sub-ecosystems created by high conductivity ground water of relatively constant temperature influencing sinkhole benthic regions. *Keywords: Lake Huron, Groundwater, Geochemistry, Karst, Ecosystems.*

RUCINSKI, D.K.[1], BELETSKY, D.[2], DEPINTO, J.V.[1], SCAVIA, D.[3], and SCHWAB, D.J.[4], [1]LimnoTech, Ann Arbor, MI, 48108; [2]Cooperative Institute for Limnology and Ecosystem Research, University of Michigan, Ann Arbor, MI; [3]School of Natural Resources and Environment, University of Michigan, Ann Arbor, MI, 48109; [4]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 48105. **3-Dimensional Water Quality Models for Assessing Hypoxia in Lake Erie.**

Hypoxia (dissolved oxygen < 2mg·L-1) in the central basin of Lake Erie has reemerged as a potential hazard to ecosystem health, despite reductions in nutrient loading required by the Clean Water Act, the Great Lakes Water Quality Agreement, and other policy changes. A suite of ecosystem models were developed to investigate the role of transport and nutrient loading to the system. The 3-dimensional model domain allows for the investigation of the near shore dynamics and the implications for hypoxia. The first model employs a simplified lower food web that focuses on the phytoplankton growth and decay processes and nutrient uptake. A framework will then be presented for adding more complex lower food web dynamics, including dreissenids and benthic algae to highlight their importance in nutrient cycling in the near shore areas. *Keywords: Mathematical models, Lake Erie, Oxygen.*

RUDRA, R.P.[1], DICKINSON, W.T.[1], KHAYER, M.[1], AHMED, S.I.[1], TUCKER, C.[2], GOEL, P.K.[2], and GHARABAGHI, B.[1], [1]School of Engineering, University of Guelph, Guelph, ON, N1G2W1, Canada; [2]Ontario Ministry of Environment, Toronto, ON, Canada. **Mapping Baseflow Dominated and Rapid Runoff Response Dominated Watersheds in Southern Ontario.**

Information regarding the dominant form of streamflow response from a watershed, i.e. slow response and baseflow dominant or rapid response and surface runoff dominant, is vital for effective and efficient management of water resources. Baseflow Indices (BFIs) were determined for 115 unregulated watersheds across southern Ontario using six available methods, and were evaluated for the discrimination of slow and rapid runoff response. The BFI values ranged widely from watershed to watershed, and from method to method. However, the values calculated by any one method were found to be highly correlated to those calculated by most other methods, resulting in the rank order of watersheds according to BFI remaining quite consistent. Therefore, relatively rapid and relatively slow response watersheds could be reliably ascertained. It was then discovered that the most rapid and slowest response watersheds were located in areas with specific Hydrologic Soil Group characteristics. A mapping of HSGs for southern Ontario was found to provide an excellent discrimination of baseflow dominated and rapid runoff dominated watersheds. These results provide an excellent backdrop for the consideration of many water management issues, including source water protection and nutrient management. *Keywords: Base flow, Great Lakes basin, Source water protection, Hydrologic budget, Nutrients, Surface runoff.*

RUDRA, R.P.[1], CHAPI, K.[1], DICKINSON, W.T.[1], GHARABAGHI, B.[1], AHMED, S.I.[1], GOEL, P.K.[2], and TUCKER, C.[2], [1]School of Engineering, University of Guelph, Guelph, ON, N1G2W1, Canada; [2]Ontario Ministry of Environment, Etobicoke, ON, M9P 3V6, Canada. **Runoff Generating Area and its Identification in a Watershed.**

More than 50% of total water quality impairment originates from non-point sources., and runoff from agricultural land is one of the major contributor to non-point sources. Therefore, the identification and quantification of runoff generation areas is crucial for source water protection and nutrient management. This paper has two focuses: i) the identification of possible approaches available in the literature to identify runoff contributing area, and ii) the development of a field procedure for identification of runoff generating areas. A wireless runoff sensor network was used in a small agricultural watershed to monitor runoff generating areas from rainfall events during late spring, summer and early fall. The results show that runoff generating areas are highly dynamic varying from 0 to 100%. About 15% of the watershed generates 75% of surface runoff during summer, 100% in fall and 45% during late spring. The factors affecting variability of runoff generating areas varies with season; however, the soil moisture and rainfall intensity play the dominant role. The sensitivity of field(s) in a watershed to runoff generation remains constant, i.e. specific fields responded first during all seasons. The results also indicate an index based on Slope and Area has a potential for the identification of sensitive fields in a watershed. *Keywords: Data acquisition, Hydrology, Watersheds, Runoff generation.*

RUDSTAM, L.G., Cornell University, 900 Shackelton Point Rd, Bridgeport, NY, 13030, USA.
 Mysids in the Great Lakes.

Great Lakes scientists are familiar with the native mysids Mysis relicta, recently renamed Mysis diluviana. That species is a key component of the food web of all Great Lakes except Erie, and often constitute a major prey of fish and as a predator, can be the dominant zooplanktivore. In contrast, the new mysids Hemimysis anomala, the first exotic mysids in the Great Lakes, is a warmwater, littoral species. Mysids in general are most common in coastal and benthic marine systems where the pelagic life history is occupied by euphausiids. For example, mysids are common on coral reefs where they are active at night and hide in crevices and caves during the day. Many littoral mysids form swarms. Thus Hemimysis has a more typical mysid-style life history and habitat choice than our native species. I will review patterns in mysid biology in lakes and coastal seas and stress the similarities and differences between the two species now present in the Great Lakes. *Keywords: Zooplankton, Zoobenthos.*

RUETZ III, C.R.[1], RENESKI, M.R.[2], and UZARSKI, D.G.[3], [1]Annis Water Resources Institute, 740 W Shoreline Dr., Muskegon, MI, 49441; [2]Department of Fisheries Biology, Humboldt State University, Arcata, CA, 95519; [3]Department of Biology, Central Michigan University, Mount Pleasant, MI.
 Round Goby Predation on *Dreissena* in Drowned River Mouth Lakes: Evidence for Spatial Heterogeneity?

Predator-prey interactions between round goby (*Neogobius melanostomus*) and *Dreissena* are an important component of the Great Lakes food web. We conducted 2 experiments to test the effect of round goby predation on *Dreissena* in drowned river mouth (DRM) lakes. First, we conducted a density-gradient experiment using 1-m^2 cages stocked with 0-15 round gobies. Round gobies significantly reduced *Dreissena* densities in all cages. Second, we conducted an exclosure experiment (treatment: no, 6-mm, 24-mm mesh) in 4 DRM lakes. Excluding round gobies did not significantly affect *Dreissena* densities in any of the lakes. Additional studies suggest that *Dreissena* were a small part of round goby diet in DRM lakes, whereas *Dreissena* were an important part of round goby diet in channel habitats (i.e., area connecting DRM lake to Lake Michigan). We suspect both species were most abundant in channel habitats because of the availability of hard substrate. Thus, we hypothesize that the strength of predator-prey interactions between round goby and *Dreissena* vary spatially across the Great Lakes depending on substrate type and predator-prey densities, which is critical for understanding food-web dynamics. *Keywords: Biological invasions, Invasive species, Dreissena, Lake Michigan, Fish.*

RUSH, S.A.[1], PATERSON, G.[1], DROUILLARD, K.G.[1], JOHNSON, T.B.[2], ARTS, M.T.[3], and FISK, A.T.[1], [1]Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, N9B 3P4; [2]Ontario Ministry of Natural Resources, Glenora Fisheries Station, Picton, ON, K0K 2T0; [3]Environment Canada, National Water Research Institute, Burlington, ON, L7R 4A6.
 Chemical Tracers Reveal Diminished Capacity of Laurentian Great Lake System to Support an Apex Native Fish Predator.

We employed chemical tracers in the form of stable isotopes ($d^{13}C$ and $d^{15}N$) and fatty acids to explore trophic relationships of Lake Trout (Salvelinus namaycush) and 5 major prey species (Alewife: Alosa pseudoharengus; Mysis: Mysis diluviana Rainbow Smelt: Osmerus mordax; Round Goby: Apollonia melanostomus; and Slimy Sculpin: Cottus cogngatus) collected in Lake Ontario during 1990 to 2008. Diets of Lake Trout and major prey species were relatively consistent across most sample years. However, for Lake Trout, $d^{13}C$ of dorsal muscle decreased linearly with the age of Lake Trout. Further, dual isotope mixing models, aimed at evaluating trophic patterns between Lake Trout and major prey species, suggest recent trophic changes with older Lake Trout foraging in deeper waters. These patterns imply that older individuals face reduced energy acquisition and this is reinforced by lower dorsal muscle lipid concentrations. We argue that reductions in the abundance of pelagic prey may be limiting the capacity of Lake Ontario to support all ages of Lake Trout. Evidence provided by our application of chemical tracers may foretell increasingly stressful conditions for predatory fishes such as Lake Trout. This tracer evidence may also suggest weakening trophic stability within this pelagic system. *Keywords: Fisheries, Food chains, Fish management.*

RUSH, S.A.[1], VERKOEYEN, S.[1], DOBBIE, T.[2], DOBBYN, S.[3], HEBERT, C.E.[4], and FISK, A.T.[1], [1]Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, N9B 3P4; [2]Point Pelee National Park, 407 Monarch Lane, RR. 1, Leamington, ON, N8H 3V4; [3]Ontario Parks, 659 Exeter Road, London, ON, N6A 4L6; [4]Environment Canada / Canadian Wildlife Service, National Wildlife Research Centre, Ottawa, ON, K1A 0H3. **Impact of Double-crested Cormorants on the Soil Characteristics of Western Lake Erie Islands.**

Animals can influence the structure of an ecosystem by changing the types and levels of nutrient input. This is of particularly consideration for the islands of western Lake Erie, which are relatively nutrient poor, but have experienced recent large increases in nesting double-creasted cormorants (Phalacrocorax auritus), threatening the health of a number of Species at Risk as well as the integrity of these unique ecological communities. The objective of this study was to assess yearly (2007–2009) and seasonal (April-October) changes in soil characteristics (nutrients, organic content, pH and the stable isotopes of carbon [d13C] and nitrogen [d15N]) of two islands, Middle and East Sister, over several levels of cormorant nesting-density (zero to high, and post-nesting). In general, with increasing cormorant nest density, soil pH decreased while NO3, total N, P and d15N increased. Within years, soil nutrient levels peaked, and pH values were at their lowest in June and July, coinciding with greatest cormorant nesting activity. Although some nutrient levels remained elevated in Post-nesting areas, soil properties such as pH evidence moderate buffering capacity. Although restoration of these ecological communities may be feasible under conditions of reduced nutrient input, these results suggest soil recovery may take >3 years. *Keywords: Lake Erie, Habitats, Cormorants.*

RUTHERFORD, E.S.[1], MASON, D.M.[1], HÖÖK, T.O.[2], JOSEPH, C.A.[3], ADLERSTEIN-GONZALEZ, S.A.[4], TYLER, J.A.[5], and JOHNSON, J.E.[6], [1]NOAA Great Lakes Environmental Research Lab, 4840 S. State Rd, Ann Arbor, MI, 48108; [2]Purdue University, 715 W. State St, W. Lafayette, IN, 47907-2061; [3]Univ. Michigan School of Natural Resources and Environment, IFR, 212 Museum Annex Bldg, 1109 N. University Ave, Ann Arbor, MI, 48109-1084; [4]Univ.

Michigan School of Natural Resources and Environment, Dana Bldg, 440 Church St, Ann Arbor, MI, 48109-1041; [5]Fisheries Projections, Inc, 307 Old Mountain Rd., Farmington, CT, 6032; [6]Michigan DNR Alpena Fisheries Research Station, 160 E. Fletcher, Alpena, MI, 49707. **Modeling Great Lakes Fish Spatial Distributions.**

Knowledge of fish spatial distributions and movements is critical for sound fisheries management, yet is poorly known for most fishes in the Great Lakes. Distributions of most fishes are known from seasonal fisheries harvest records or annual surveys of fish biomass. Analysis of coded-wire tag data and telemetry data for a few select species has provided information on species distributions and movements, but has rarely been associated with environmental data. In this paper we review recent papers, quantitative approaches and technology that promise to advance the knowledge of fish spatial distributions and movements in the Great Lakes. *Keywords: Salmon, Spatial analysis, Management.*

RUTTER, M.A., Penn State Erie, The Behrend College, 4205 College Drive, Erie, PA, 16563. **A Statistical Approach for Establishing Tumor Incidence Delisting Criteria in Areas of Concern: a Case Study.**

The Great Lakes Water Quality Agreement specifies "fish tumors or other deformities" as one of the 14 beneficial use impairments that can be used to declare a geographic area in the Great Lakes an Area of Concern (AOC). The International Joint Commission has suggested by that the fish tumor impairment can be delisted when fish tumor incidence in the AOC does not exceed rates at unimpacted control sites. This paper presents a statistical technique utilizing Bayesian hierarchical logistic models to estimate tumor incidence in an AOC and in candidate least impacted control sites (LICS). Liver and skin tumor incidence are estimated using age, length, weight, and gender as possible covariates using a hierarchical framework to account for a sampling design in which sites are sampled over multiple years and/or at multiple sub-locations within the site. The posterior distributions of tumor incidence can then be used to identify LICS for the watershed and subsequently compare the tumor incidence in the AOC to the LICS using a Bayesian form of the two one-side tests for equivalence procedure. Presque Isle Bay (Erie, PA) in the Lake Erie watershed is used as a case study to demonstrate the technique. *Keywords: Fish tumors, Areas of Concern, Lake Erie.*

RYAN, D.J.[1], HÖÖK, T.O.[1], SEPÚLVEDA, M.S.[1], and NALEPA, T.F.[2], [1]Purdue University, 715 West State St., West Lafayette, IN, 47907; [2]Great Lakes Environmental Research Laboratory, NOAA, 4840 S. State St., Ann Arbor, MI, 48108. **Short-term Condition Assessment and Comparison of *Diporeia* spp. Populations in the Great Lakes Region.**

Over the past two decades *Diporeia* in all of the Laurentian Great Lakes, except Superior, have declined dramatically. These declines have coincided with the expansion of *Dreissena polymorpha* and *D. bugensis*, however the mechanisms underlying declines remain unclear. We used RNA:DNA ratios to index short-term growth and condition of *Diporeia*. We conducted a series of experiments to evaluate the utility of RNA:DNA as a metric of condition for *Diporeia*. In addition, during 2008-2009 we collected *Diporeia* from throughout the Great Lakes and

Cayuga Lake (New York) and evaluated the spatial and temporal variation of short-term growth rate. Our experiments demonstrate that RNA:DNA ratios of *Diporeia* respond to temperature and periods of starvation. Further RNA:DNA measurement of field collected *Diporeia* revealed a high degree of spatial and temporal variation which may be indicative of differential growth condition among populations *Keywords: Diporeia, RNA:DNA, Dreissena, Condition, Bioindicators.*

RYAN, D.J.[1], HÖÖK, T.O.[1], NALEPA, T.F.[2], and LOFGREN, B.M.[2], [1]Purdue University, 715 West State St., West Lafayette, IN, 47907; [2]Great Lakes Environmental Research Laboratory, NOAA, 4840 South St., Ann Arbor, MI, 48108. **Development and Application of a Bioenergetics Model for *Diporeia* spp. in Lake Michigan.**

Historically, *Diporeia* spp. were abundant in the Great Lakes and dominated benthic community consumption. In recent years, however, *Diporeia* populations have declined seemingly in response to *Dreissena* spp. introduction and expansion. Bioenergetics models are commonly used to estimate consumption of organisms from observed growth patterns and environmental conditions. We parameterized a *Diporeia*-specific bioenergetic model from previous literature, and we used the model to investigate historical *Diporeia* consumption pre- and post-dreisssenid establishment. We acquired data pertaining to Lake Michigan *Diporeia* growth, water temperature, energy density and abundance as input for the model from previous studies and targeted measurements. Comparisons of lake-wide *Diporeia* consumption before and after declines indicate that consumption totals have dramatically decreased over the past two decades. In comparison, lake-wide filtering rates of *Dreissena* spp. far exceed historic *Diporeia* consumption rates. *Keywords: Diporeia, Consumption, Bioenergetics, Dreissena.*

SABORIDO BASCONCILLO, L., BACKUS, S., STRUGER, J., LEE, H.B., SMITH, K., and SOUTHWOOD, T., Canada Centre for Inland Waters, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Occurrence of Bisphenol A in the Canadian Aquatic Environment.**

Bisphenol A (BPA) is widely used in the production of polycarbonate plastics, epoxy resins and flame retardants. This alkylphenol is ubiquitous in the aquatic environment, biota and human tissues from all over the world. BPA is a xenoestrogen and a well-studied endocrine disruptor. Recent research has shown that environmental levels of BPA could be involved in the development of certain cancers, hypertension, diabetes and obesity in humans. BPA is also suspected to bioaccumulate and biomagnify in the food chain. Thus, it has been proposed to set a release limit for BPA in industrial effluents in Canada. The main goal of this study was to provide information regarding BPA levels in the Canadian aquatic environment. BPA was measured in 35 locations across Canada and it was detected in 57% of the samples, mainly in those sites associated with urban activities. BPA levels in rivers in Canada were in the range of 0.005-0.060 µg/L. The maximum concentration measured in water was 3.7 µg/L in Hamilton's harbor. This site was selected to study BPA's bioaccumulation and biomagnification potential in a food web. BPA was investigated in seven fish species representative of various trophic levels. *Keywords: Water quality, Environmental contaminants, Bioaccumulation.*

SADRADDINI, S.[1], AZIM, E.[1], BHAVSAR, S.[2], and ARHONDITSIS, G.B.[1], [1]University of Toronto, Toronto, ON; [2]Ontario Ministry of the Environment, Toronto, ON. **Spatiotemporal Trends of PCB Contamination in Lake Erie Fish Communities: A Bayesian Approach.**

We examine the spatiotemporal trends of PCB contamination in Lake Erie fish using a statistical modeling framework founded upon Bayesian inference techniques. First, we use an exponential decay model to quantify the declining rates in intensively studied species (walleye, white bass, and coho salmon), while first-order stochastic terms are included to accommodate non-monotonic patterns in the time series. Although the observed concentrations in skinless boneless fillet (SBF) of walleye are lower than in whole fish (WF) data, our analysis suggests that the declining rates are somewhat higher in walleye WF than in walleye SBF. Then, we introduce a hierarchical configuration of the double exponential model to identify the trends in less intensively studied fish species. The same hierarchical approach is used to detect differences among the different locations of the lake. Finally, linear dynamic modeling examines the annual concentrations and the associated rates of change in SBF data, while accounting for the role of the fish length. Generally, our analysis suggests that the PCB concentrations are not characterized by a systematic change in recent years. The latter result contrasts the increasing trends in mercury concentrations, which appear to be particularly evident since the mid-90s. *Keywords: Mercury, Risk assessment, PCBs, Fish management, Bayesian inference, Ecosystem forecasting.*

SAWYER, J.[1], GANDHI, N.[2], DIAMOND, M.[1], ARHONDITSIS, G.[1], and KOOPS, M.[3], [1]Department of Geography, University of Toronto, 100 St. George St., Toronto, ON; [2]Department of Chemical Engineering, University of Toronto, 200 College Street, Toronto, ON; [3]Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, Burlington, ON. **Examining the Transfer and Accumulation of Polychlorinated Biphenyls (PCBs) and Polyunsaturated Fatty Acids (PUFAs) through the Bay of Quinte Food Web.**

Many fish populations in Lake Ontario are subject to human consumption restrictions due to elevated polychlorinated biphenyl (PCB) concentrations. PCBs contribute to several beneficial use impairments in the Bay of Quinte, including degradation of fish and wildlife populations, reproduction and deformities, and restrictions on fish and wildlife (De Solla et al., 2007, Hall et al., 2006). However, the negative aspects of fish consumption must be balanced against the beneficial effects, namely the high concentration of polyunsaturated fatty acids (PUFAs) associated with numerous health benefits. As both PCBs and PUFAs biomagnify through the aquatic food web, ecosystem changes could impact their transfer through the aquatic system and ultimately their concentrations in higher trophic level organisms. We used fugacity-based and ecosystem-based models to quantify and compare the transfer and accumulation of PCBs and PUFAs through the Bay of Quinte's food web. We compare factors leading to the bioaccumulation and biomagnification of PCBs and PUFAs such as trophic status and food web length. *Keywords: Polyunsaturated Fatty Acids (PUFAs), Biomagnification, Hamilton Harbour, Bay of Quinte, Food chains.*

SAXTON, M.A.[1], BOURBONNIERE, R.A.[2], and WILHELM, S.W.[1], [1]Department of Microbiology, University of Tennessee, Knoxville, TN, 37996; [2]Environment Canada, National Water Research Institute, Burlington, ON, L7R 4A6. **Phosphonate Influence of Phytoplankton Community Structure in Lake Erie.**

Widespread use of the phosphonate herbicide glyphosate has lead to measurable levels of this chemical and its primary breakdown product aminomethyl phosphonic acid in streams and lakes throughout North America. Glyphosate and related compounds have been shown to be available to the microbial community as a nutrient source, and to influence phytoplankton community structure due to the herbicidal properties of the chemical. We are investigating the influence of glyphosate on Lake Erie phytoplankton community structure through microcosm experiments testing the hypothesis that loading of this compound alters algal community composition. Significant increases of both chl *a* and the toxic filamentous cyanobacterium *Planktothrix* were observed in an incubations with a low starting N:P ratio of 6. Incubations performed the following year at the same site with a similar algal community, but much higher N:P (52) did not show the same increases in chl *a* or *Planktothrix* spp. Controlled experiments in the laboratory coupled with DNA sequence analysis of cyanobacterial communities is being used to analyze the community members influenced by phosphonate addition. These results indicate that chemical speciation of nutrients as well as relative nutrient concentrations influence phytoplankton community structure. *Keywords: Lake Erie, Glyphosate, Harmful algal blooms.*

SCAVIA, D.[1], MIDA, J.L.[1], FAHNENSTIEL, G.L.[2], POTHOVEN, S.A.[2], VANDERPLOEG, H.A.[3], and DOLAN, D.M.[4], [1]University of Michigan School of Natural Resources and Environment, Dana Building, 440 Church St., Ann Arbor, MI, 48109; [2]Lake Michigan Field Station/NOAA/GLERL, 1431 Beach St,, Muskegon, MI, 49441; [3]NOAA/GLERL Headquarters, 4840 S. State Rd., Ann Arbor, MI, 48108; [4]University of Wisconsin-Green Bay, Natural and Applied Sciences, 2420 Nicolet Drive, Green Bay, WI, 54311. **Long-term Monitoring Programs Reveal Recent Changes in Lake Michigan Primary Production.**

We used results from two monitoring programs to explore long-term and recent changes in southern Lake Michigan water quality. NOAA's long-term monitoring program in southeast Lake Michigan provides detailed temporal resolution, but limited spatial coverage; whereas the US EPA's Great Lakes National Program Office monitoring program provides more spatial coverage, but limited temporal resolution. We describe changes in total phosphorus (TP), silica, nitrate plus nitrite, and chlorophyll concentrations and TP loads in the southern basin from the period before invasive dreissenid mussel influence (1983-1999) to the post-invasion period (2000-2008). TP decreased at both sets of stations over the study period. A significant decrease in spring chlorophyll concentrations was observed at the NOAA stations post-2000, but there were no significant changes in summer chlorophyll concentrations in either dataset. The lake's Si reservoir increased over the study period. Basin-scale spring isothermal Si concentrations increased gradually, whereas SML Si increased dramatically after 2003, likely reflecting reduced diatom production. The timing and nature of these changes suggest that dreissenid mussel filtering has dramatically reduced spring phytoplankton abundance and production across the entire southern basin of Lake Michigan. *Keywords: Lake Michigan, Monitoring, Water quality.*

SCHANTZ, S.L.[1], CLAFLIN, J.A.[2], AGUIAR, A.[1], GARDINER, J.C.[3], SWEENEY, A.M.[4], and PECK, J.D.[5], [1]University of Illinois, 2001 S. Lincoln Ave., Urbana, IL, 61802; [2]University of Florida, 471 Mowry Road, Gainsville, FL, 32611; [3]Michigan State University, B629 West Fee, East Lansing, MI, 48824; [4]Texas A & M University Health Sciences Center, Tamu 1266, College Station, TX, 77843; [5]University of Okalahoma Health Sciences Center, 801 NE 13th Street, Oklahoma City, OK, 73104. **Fish Consumption Patterns in Recent Hmong Immigrants Living in Northeastern Wisconsin.**

Fish consumption practices and awareness of fishing advisories among recent Hmong immigrants in Green Bay, Wisconsin were assessed. Respondents recalled their fish consumption in the previous 12 mo, including frequency of fish meals, species of fish consumed and locations of fish caught, and were asked about their awareness of the Wisconsin Fishing Advisories. Seventy percent of the 385 respondents had consumed fish from local waters in the past, but a smaller percentage (49%) had eaten locally caught fish during the previous 12 mo. The frequency of fish consumption was low, with a median of only 4 meals/year. White bass and smallmouth bass were the most frequently consumed species and the Oconto River, Wolf River and Lake Winnebago were the waters most frequently fished. Only 14% had ever consumed fish from the highly PCB-polluted Fox River and less than 7% had consumed fish from the Fox River during the previous 12 mo. Almost 90% were aware of the fishing advisories and 84% had changed their fish consumption in response to the advisories. The most frequent responses were that they no longer ate fish, reduced the amount of fish eaten or changed fishing locations. Based on the fishing locations reported it appears that the Hmong are avoiding the most heavily contaminated waterways. Funded by TS000008, ES11263 and R82939001. *Keywords: Fish, Human health, Toxic substances.*

SCHLAIS, M., MUKHERJEE, M., MCKAY, R.M., and BULLERJAHN, G.S., Department of Biological Sciences, Bowling Green State University, Bowling Green, OH, 43403. **Detection and diversity of bacterial and archaeal ammonia oxidation genes (*amoA*) in Lake Superior.**

Nitrate concentrations in Lake Superior have increased 5-6 fold over the past century, and prior work has indicated that such increases have arisen due to biological in-lake processes. We have used PCR to detect the presence of nitrifying microbes responsible for ammonia oxidation, using PCR primers to amplify the *amoA* gene, encoding a subunit of the ammonia monooxygenase gene. To date, bacterial and archaeal *amoA* sequences have been obtained from pelagic stations, reflecting the presence of ammonia-oxidizing Betaproteobacteria and Group I Crenarcheota. Phylogenetic analysis suggests that the endemic ammonia oxidizers are of low diversity and may represent novel groups of microbes endemic to Lake Superior. Analysis of enrichment cultures indicate that mixed cultures contain bacterial and archeal nitrifyers that reflect the natural diversity detected in our environmental DNA samples. *Keywords: Nitrification, Microbiological studies, Lake Superior.*

SCHMITT-MARQUEZ, H.S.[1], CHAPRA, S.C.[2], and DOLAN, D.M.[3], [1]University of Wisconsin - Green Bay, Environmental Science and Policy Program, Green Bay, WI, 54311; [2]Tufts

University, Civil and Environmental Engineering, Medford, MA, 2155; [3]Univerity of Wisconsin-Green Bay, Natural and Applied Sciences, Green Bay, WI, 54321. **Phosphorus Loading Trends in the Upper Great Lakes System, 1994 – 2008.**

The bi-national Great Lakes Water Quality Agreement of 1972 established a major commitment to monitor and restore the health of the Great Lakes ecosystem. Particular concern over existing pollution in Lakes Superior and Huron resulted in a request to the IJC for a comprehensive research effort to examine the condition of the Upper Lakes. The Upper Lakes Reference Group was appointed by the IJC to conduct this research, and submitted a report outlining the basin characteristics, water and land uses, and estimates of the load contributions to the lower lakes. Annex 3 of the GLWQA (1978) established phosphorus target loads for each basin, and a vital component to upholding those targets is the continuous process of data gathering and analysis to ensure compliance. The results of this research provide loading trends for the past fifteen years that are critical to the understanding and further analysis of lake processes. In addition, a lakes- in-series model will demonstrate how the load contributions of the Upper Lakes and Lake Michigan affect the lower lakes, especially Lake Erie. By treating the Lakes as one interconnected system, the model will account for loading effects from the Upper Lakes, thereby providing a clearer understanding of the relative contributions of sources of total phosphorus. *Keywords: Pollution load, Mass balance, Phosphorus.*

SCHOCK, N.T., UZARSKI, D.G., and WEBSTER, W.C., 910 Glen Ave, Mt. Pleasant, MI, 48858. **Impacts of Anthropogenic Disturbance on Fish and Macroinvertebrate Populations Among Great Lakes Coastal Wetlands.**

Great Lakes coastal wetlands experience temporary, seasonal and long term water level changes. During times when lake water recedes below normal levels, areas that were previously inundated are left exposed. This makes it easy for riparian property owners (private and public) to manipulate wetland structure and eliminate valuable wetland area. We hypothesize this habitat alteration has significant impacts on the fish and invertebrate communities that live in these nearshore areas. Biotic community data was sampled from disturbed and reference sites using fyke nets and dip nets respectively. Data collected at reference sites acted as the control and were acquired 200 to 500m from each disturbance. Pairwise analysis was used to determine the affect these unnaturally created habitats had on fish populations. Relationships between invertebrate and fish structure was also analyzed. The data collection protocol used in this study also made it possible to assess the quality of these wetlands using the fish based Index of Biotic Integrity created by Uzarski in 2005. Conclusions from this study help us understand how anthropogenic manipulation of wetlands change habitat structure and the biotic communities found in these areas. *Keywords: Fish, Water level, Macroinvertebrates.*

SCHUSTER, L.E. and WATZIN, M.C., University of Vermont, 3 College St, Burlington, VT, 5401. **The Molecular Diversity of the Cyanobacterium *Microcystis* and its Relationship to Toxin Production in Lake Champlain.**

For the last decade, Lake Champlain has experienced summer blooms of harmful cyanobacteria. Accumulations have been most dense in Missisquoi Bay, where blooms have occurred 9 of the 10 years. The genus *Microcystis* is of particular concern because it produces a hepatotoxin (microcystin) that poses both public drinking water and recreational use threats. Our data set shows that higher cell densities are not always associated with higher toxin levels. Because not all cells will contain the genes necessary to produce microcystin, we are investigating what fraction of the *Microcystis* population is able to produce toxin. To determine which cells contain the toxin genes we have adapted a quantitative polymerase chain reaction (qPCR) assay for *Microcystis*, assaying for both the *mcyD* and MIC genes. Microcystin concentrations have also been measured by enzyme linked immunosorbent assay (ELISA) and vary from 0 to >1000 µg/L. Microcystin concentrations, cell densities and species composition, and abundance of the *mcyD* and MIC genes are being compared to estimate the fraction of the *Microcystis* population that contains the toxin gene. Finally, multivariate analyses of these data and environmental factors will be used to explore which factors may be associated with toxin production. *Keywords: Cyanophyta, Harmful algal blooms, Genetics.*

SCHWAB, D.J.[1], WANG, J.[1], LANG, G.A.[1], and LAPLANTE, R.E.[2], [1]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Road, Ann Arbor, MI, 48108; [2]NOAA National Weather Service, Federal Facilities Building Cleveland Hopkins Airport, Cleveland, OH, 44135. **Evaluation of Great Lakes Ice Model (GLIM) Real-time Ice Forecasts for Lake Erie during the 2009-2010 Ice Season.**

The Great Lakes Ice Model (GLIM) is an experimental numerical forecast model intended to improve the accuracy of Great Lakes ice forecasts and outlooks, open lake forecasts, near shore forecasts and marine weather statements. The GLIM runs twice per day as part of the Great Lakes Coastal Forecast System (GLCFS) at NOAA/GLERL (http://www.glerl.noaa.gov/res/glcfs). GLIM is a combination of the Princeton Ocean Model for hydrodynamics and the Combined Ice Ocean Model (CIOM) ice model specifically tailored for operation in the Great Lakes. The combined lake circulation/ice model is run using the latest National Digital Forecast Database (NDFD, http://www.nws.noaa.gov/ndfd) surface meteorological fields as input. Twice-a-day forecasts extend out to 5 days. The initial conditions are based on nowcast runs which incorporate the NIC ice observations and use observed meteorological data for atmospheric forcing. The integration of the GLIM and the NDFD forecast elements generates graphics and text products showing ice concentration, ice thickness and ice drift. Nowcasts and forecasts of ice concentration fields are compared to twice-weekly ice analysis charts produced by the National Ice Center as well as satellite imagery from active (SARSAT) and passive (MODIS) sensors. *Keywords: Ice, Lake Erie, Model testing.*

SCHWEITZER, S.A. and COWEN, E.A., DeFrees Hydraulics Laboratory, School of Civil & Environmental Engineering, Cornell University, 220 Hollister Hall, Ithaca, NY, 14850. **The Water Quality of a Shallow Shelf Connected to a Deep Lake as Forced by Tributary Flow Events and Internal Waves.**

Cayuga Lake is a long (60 km) and narrow (4 km) lake with a shallow southern shelf. 40% of the watershed's surfaces runoff enters the lake on the shelf, along with effluent from two municipal wastewater treatment plants and cooling water from a utility. Large temporal and spatial variance exists in water quality on the shelf, with significant temporal variance observable on both seasonal and shorter time scales. Using an 11 year bi-weekly water quality monitoring record augmented by hydrodynamic measurements we will show that exchange between the shelf and main body of the lake is controlled by high tributary flow events and the run up of internal waves onto the shelf. Under upwelling conditions parts of the shelf become isolated from the main body of the lake, causing spikes in nutrient concentration due to external loading. During less extreme forcing conditions the differences in run up height of internal waves on to different parts of the shelf (due to bathymetry and effects of the earth's rotation) cause variability in mixing and exchange with the main body basin of the lake, creating significant gradients in nutrient availability and phytoplankton (as measured by chlorophyll-a levels). *Keywords: Intermittent processes, Hydrodynamics, Internal waves, Physical limnology.*

SEABROOK, S.R.[1], OVEISY, A.[1], and HALL, K.R.[2], [1]H.C.C.L. Consultants, Suite 106 Royal Artillery Park, 348 Bagot Street, Kingston, ON, K7K 3B7; [2]University of Guelph, Guelph, ON, N1G 2W1. **Considerations for IPZ-3 Delineations at Great Lake Intakes.**

As focus at Great Lake intakes move from IPZ-1 and IPZ-2 towards defining IPZ-3 regions, the environmental conditions which may be critical for transport of contaminants from source to intake becomes increasingly complex. While IPZ-2 boundaries are generally based on relatively intense probabilistic environmental inputs, the IPZ-3 boundaries may be determined based on much longer duration conditions. As the duration of the wind and wave events driving in-water velocity increases, their intensity decreases and variability (in magnitude and direction) increases. Furthermore, where concentrations of contaminants transported to the intake are to be considered in comparison to threshold values, the highly energetic events may not be the events of critical importance. Therefore, the relative influence and importance of the various driving variables and in-water processes becomes more uncertain and modelling must accommodate these uncertainties. Preliminary IPZ-3 analyses suggest that relatively stable wind conditions can persist in excess of 24 hours at some locations. Such persistence is expected to generate IPZ-3 regions extending 10's of km from the respective intakes. This presentation highlights preliminary IPZ-3 considerations, and discusses sensitivity of the IPZ-3 zones to variability of input conditions. *Keywords: Coastal processes, Sourcewater protection, Hydrodynamics, Environmental policy.*

SEAMAN, L.M., 35 E. Wacker Dr., Suite 1850, Chicago, IL, 60601. **Assessing and Managing Water Use Impacts in the Great Lakes Basin.**

In 2005, the Great Lakes Governors and Premiers signed the Great Lakes—St. Lawrence River Basin Sustainable Water Resources Agreement. Additionally, the Governors endorsed the interstate Great Lakes—St. Lawrence River Basin Water Resources Compact which became law on December 8, 2008. This presentation focuses on efforts to assist State and Provincial staff with meeting the commitments of the Agreement and Compact. Specifically, the Council of

Great Lakes Governors is working with water managers to make available information to assess individual and cumulative impacts while meeting broad management goals. The presentation will discuss water use regulations, decision support information and methods to assess cumulative impacts. These efforts are also aimed at helping with the development of a cumulative assessment process and creating tools for adaptive management. *Keywords: Collaboration, Great Lakes basin, Cumulative Impact Assessment, Water Use Impacts.*

SHEN, L.[1], REINER, E.[2], MACPHERSON, K.[2], KOLIC, T.[2], BURNISTON, D.[3], HELM, P.[2], RICHMAN, L.[2], HILL, B.[3], BRINDLE, I.[1], and MARVIN, C.[3], [1]Department of Chemistry, Brock University, St. Catharines, ON, L2S 3A1; [2]Ontario Ministry of the Environment, Toronto, ON, M9P 3V6; [3]Environment Canada, Burlington, ON, L7R 4A6. **Halogenated Norbornene Flame Retardants in the Great Lakes Tributaries.**

Water quality of the Great Lakes tributaries is monitored by Environment Canada and the Ontario Ministry of the Environment to provide information on contaminant loadings to the lakes and identify potential "problem" watersheds. Dechlorane 602 (Dec 602), Dechlorane 603 (Dec 603), Dechlorane 604 (Dec 604) and Dechlorane Plus (DP) are flame retardant substitutes of mirex. In this study, concentrations and spatial trends of these dechlorane flame retardants in surficial sediments collected from Canadian tributaries of Lakes Superior, Huron, Erie, and Ontario are reported. The highest concentrations of Dec 602, 604, and DP were found in the Niagara River sediments at 12 ng/g dry weigt, 4.8 ng/g dry weigt, 310 ng/g dry weigt, respectively. These three dechlorane compounds also had similar spatial trends in tributary sediments across the Great Lakes basin, indicating that manufacturing plants along the Niagara River are important sources of Dec 602, 604 and DP to the Great Lakes. The highest concentration of Dec 603 (1.1 ng/g dry weigt) was detected in one tributary sample of Lake Erie, and the spatial trend of Dec 603 is different from those of Dec 602, 604, and DP. The source of Dec 603 to the Great Lakes requires further investigation. *Keywords: Flame retardants, Sediments, PBTs.*

SHEPPARD, K.T., HANN, B.J., and DAVOREN, G.K., University of Manitoba, Department of Biological Sciences, 121 Machray Hall, Winnipeg, MB, R3T 2N2. **Impacts of Invasive Rainbow Smelt (*Osmerus mordax*) on Lake Winnipeg Food Web Including Commercially Important Walleye (*Sander vitreus*).**

Invasive species can have both negative and positive impacts on the trophic structure of aquatic systems. Rainbow smelt, first observed in Lake Winnipeg during late 1990, have an undetermined impact on upper and lower trophic levels. Walleye is a commercially important species in the lake and a potential predator of rainbow smelt. Since smelt were observed, walleye populations appear to be thriving and catches have increased. To determine impacts of this invasive species, dietary composition of these species must first be elucidated. During mid-Summer 2009, gut contents of ten walleye of four size classes (fork lengths: 181-280 mm, 281-380 mm, 381-480 mm and 481-580 mm) were sampled via. gill-netting from 3 locations in the North Basin. Gut contents were analyzed for otolith remains that were identified and measured. Fork lengths of consumed smelt were determined using a linear regression of otolith and fork

Water quality improvements coincided with sewage treatment plant upgrades as well as zebra mussel establishment, and the relative importance of these factors will be addressed. *Keywords: Water quality, Severn Sound, Remediation, Zebra mussels, Eutrophication.*

SHIMODA, Y., AZIM, E., PERHAR, G., RAMIN, M., GUDIMOV, A., SADRADDINI, S., and ARHONDITSIS, G.B., University of Toronto, Toronto, ON. **Our Current Understanding of Lake Ecosystem Response to Climate Change: What Have We Really Learned from the North Temperate Deep Lakes?**

Climatic change is increasingly recognized as an important regulatory factor, capable of influencing the structural properties of aquatic ecosystems. The main objective of our study is to update the current state of knowledge on documented climate-induced changes on lake phenology. We first review what we have learned from several north temperate deep lakes with respect to the ability of climate in modulating the interactions among lake hydrodynamics, chemical factors, and food web structure. Our aim is to assess the existence of long-term trends in the physical (temperature, timing of stratification, duration of ice cover), chemical (nutrient concentrations), and biological (timing of the spring bloom, phytoplankton composition, zooplankton abundance) characteristics of the lakes; to examine the signature of local weather conditions (air temperature, rainfall) and large-scale climatic variability (ENSO, PDO) on the lake physics, chemistry and biology; and to identify the underlying mechanisms that drive these ecological patterns. We also attempt to delineate the climate change vis-à-vis nutrient loading effects on lake phenology by conducting modelling experiments that focus on the relative changes of the major causal associations underlying plankton dynamics during the spring bloom and the summer stratified period. *Keywords: Biogeochemistry, Structural equation modeling, Climate change, Phenology, Ecosystem forecasting, Plankton dynamics.*

SHORT, S.M., SHORT, C.M., RUSANOVA, O., STANIEWSKI, M.A., and MUSRAP, N., University of Toronto Mississauga, Mississauga, ON, L5L 1C6. **The Molecular Ecology of Algal Viruses in Lake Ontario.**

Efforts to characterize algal virus communities in Lake Ontario were initiated in September 2007 by studying a conserved marker gene for phycodnaviruses (viruses that infect eukaryotic phytoplankton). These efforts revealed a diverse community of viruses closely related to marine prasinophyte viruses, yet chloroviruses, the only phycodnaviruses known from freshwater environments, were surprisingly absent in September 2007 Lake Ontario samples. Eventually, modified molecular techniques permitted detection of Lake Ontario chloroviruses and marine prymnesioviruses in a nearby stormwater management pond. Using a genetic marker for photosynthesis, candidate phycodnavirus hosts, and diverse communities of cyanobacteria and their phages were also observed in Lake Ontario samples. Weekly quantification of several different phycodnavirus genes over more than 2 years demonstrated that different viruses had different peak abundances and seasonal timing, and that some viruses were able to persist at remarkably low abundances throughout the year. The fact that the seasonal timing of some phycodnaviruses appeared predictable implies that aspects of their hosts' life histories are

similarly predictable, and incorporation of virus-induced mortality into models of Lake Ontario's microbial food web should be tractable. *Keywords: Phytoplankton, Viruses, Lake Ontario.*

SHUCHMAN, R.A.[1], LESHKEVICH, G.[2], HATT, C.R.[1], POZDNYAKOV, D.V.[3], and SAYERS, M.J.[1], [1]Michigan Tech Research Institute, 3600 Green Court, Suite 100, Ann Arbor, MI, 48105; [2]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48108; [3]Nansen International Environmental and Remote Sensing Center, 7, 14 Line Street, St. Petersburg, Russia. **An Operational MODIS Algorithm for the Retrieval of Chlorophyll, Dissolved Organic Carbon, and Suspended Minerals for All Laurentian Great Lakes.**

The MTRI/NIERSC algorithm retrieves concentrations of chlorophyll (CHL), dissolved organic carbon (DOC) or more correctly CDOM, and suspended minerals (SM). The algorithm can use MODIS, SeaWiFS or MERIS electro-optical data as input. The initial model was validated (Pozdnyakov et al., 2005) and applied in a seven-year inter-annual analysis of SeaWiFS data in Lake Michigan (Shuchman et al., 2006). The refinement of the algorithm to work on MODIS data in an operational capacity to support the generation of CHL, DOC, and SM estimates for all the Great Lakes on cloud-free days is the goal of this project. The algorithm uses, and its performance is dependent on, a hydro-optical (HO) model that consists of the absorption and backscatter coefficients for CHL, DOC, and SM for each satellite band. The original work utilized a proxy HO model based on some historical Lake Ontario observations. The new all lakes MODIS algorithm is based on a HO model created using data from NOAA/GLERL sponsored cruises in each lake. *Keywords: Great Lakes basin, Algorithm, Satellite technology, Water quality.*

SHUCHMAN, R.A.[1], BROOKS, C.N.[1], SAYERS, M.J.[1], JENKINS, L.K.[1], MEADOWS, G.A.[2], BROWN, H.C.[2], VAN SUMEREN, H.W.[3], and AUER, M.T.[4], [1]Michigan Tech Research Institute, 3600 Green Court, Suite 100, Ann Arbor, MI, 48105; [2]University of Michigan, Marine Hydrodynamics Laboratories, Ann Arbor, MI, 48109-1107; [3]Great Lakes Water Studies Institute, Northwestern Michigan College, Traverse City, MI, 49686; [4]Michigan Tech University, 1400 Townsend Drive, Houghton, MI, 49931; [5]Michigan Tech University, Houghton. **A New Remote Sensing Algorithm for Mapping Cladophora in the Great Lakes.**

A new remote sensing algorithm has been developed to map Cladophora extent and biomass in the near-shore waters (0-15 meters depth) of the Great Lakes. The algorithm is based on the earlier work of Lyzenga (Lyzenga 1978, 1981; Lyzenga et al., 2006) and utilizes the blue, green, and red visible bands of electro-optical satellites such as Landsat TM and higher spatial resolution (~2m) commercial multispectral data from GeoEye and DigitalGlobe. The algorithm maps Cladophora using a depth invariant bottom reflectance index and has been successfully tested on Landsat TM and GeoEye-1 data sets of the Sleeping Bear Dunes National Lakeshore (SBDNL) in Lake Michigan. Overall correct classification accuracies of 89% and 84% for two different "ground truth" collections verified that the depth invariant index algorithm can in fact accurately map Cladophora. The biomass estimates were generated using diver-obtained algae samples of one meter diameter sampling areas on the lake bottom. The dry weight of sampled

Cladophora mass representing those areas were then correlated to depth corrected remote sensing signatures. The calibrated (i.e. wet biomass amount) remote sensing pixels were then summed to obtain total biomass within the SBDNL. The algorithm is being used to track temporal changes in Cladophora extent. *Keywords: Cladophora, Algorithm, Remote sensing, Great Lakes basin.*

SILVA, M.R. and MCLELLAN, S.L., 600 E Greenfield Ave, Milwaukee, WI, 53204, US. **The Sources and Nearshore Transport of Human Fecal Pollution in Lake Michigan Beaches.**

Lake Michigan is an important source of freshwater and is noted for its recreational and economical importance for the Great Lakes region. Therefore, keeping the waters safe is crucial. To investigate the sources and transport of fecal pollution at Lake Michigan beaches and the health risk associated with swimming at these beaches, the nearshore waters of 11 beaches in Milwaukee, Wisconsin, were examined for fecal pollution indicators during 2008-2009. The *Bacteroidales* human fecal pollution marker was detected in 40% of stormwater outfall samples (n=179) in 2008 and 39% from outfall samples (n=111) in 2009. This demonstrated that sanitary sewage contamination is a major concern. The marker was detected in 17/100 (17%) beach water samples in 2008 and 26/231 samples (11%)in 2009. The majority of positive samples of outfalls and beach water were at four of the beaches. Detection of the human marker in water was very frequent in beaches that have directly discharge of outfalls. There was no occurrence of the human marker in Bradford Beach in 2009 since installation of the rain gardens in 2008, which captured runoff from the outfalls. This data will be used to build a statistical regression model expected to predict when the bacterial concentration of the beach water was above or below the level considered safe for swimming. *Keywords: Coastal engineering, Pollution sources, Environmental contaminants.*

SIMMONS, L.J., SANDGREN, C.D., BERGES, J.A., and ENGEVOLD, P.M., University of Wisconsin-Milwaukee, Biological Sciences, Milwaukee, WI, 53211. **Application of High-Performance Liquid Chromatography (HPLC) for Interpretation of Nutrient-Phytoplankton-Zooplankton Interactions in the Great Lakes.**

Nutrient stress and herbivore effects on phytoplankton in the Great Lakes are most frequently assessed using algal biomass responses, measured as chlorophyll *a*. Such community-level interpretations are invaluable, but lack insight regarding potentially divergent responses of the individual taxonomic groups that compose the phytoplankton. This insight can be of critical importance for predicting long-term community changes resulting from alterations of nutrient supply and foodweb composition. An approach to obtaining such information without the tedium and expense of species enumeration is HPLC analysis of group-specific accessory pigments. Here we present the results of nutrient bioassay and herbivore gradient experiments performed during the summer of 2008 in Lake Michigan. Experiments are first interpreted on the basis of traditional chlorophyll *a* analyses, and then further analyzed on the basis of algal group-specific indicator accessory pigments. Differences in responses among algal taxonomic groups to the community manipulations will be emphasized. *Keywords: Nutrients, HPLC, Phytoplankton, Zooplankton.*

SIMPSON, H.C.[1] and DE LOË, R.C.[2], [1]1 Stone Road West, 3rd Floor Se, Guelph, ON, N1G 4Y2; [2]200 University Avenue West, Waterloo, ON, N2L 3G1.
A Role for More Collaborative Approaches to Environmental Decision-Making.

Decision-making has traditionally been supported by traditional risk analysis using scientific information. However, decision-making involving wicked problems, such as those often encountered in source water protection (SWP), is 'quasi-scientific' because more than scientific knowledge needs to be considered. Thus, the literature indicates that a broader risk analysis approach is needed to address the kinds of wicked problems that occur in SWP. In particular, members of affected communities need to be involved throughout the decision-making process so that local experiential knowledge and societal values can be incorporated more effectively. This is a difficult challenge that requires a shift from an inwardly-focused technical process to a more open process involving members of affected communities in all aspects of water management and protection. This paper describes how such an approach can bring together experts and stakeholders to share scientific and stakeholder knowledge, incorporate societal values, and help create a common or 'vernacular' knowledge, during the decision-making process. A case study is provided that demonstrates how such a collaborative approach can be incorporated into the development of a water management program. *Keywords: Wicked problems, Public participation, Collaboration, Risks, Decision making.*

SINGER, J.[1], MANLEY, T.O.[2], HUGHES, W.[1], and MANLEY, P.[2], [1]Earth Sciences, SUNY-Buffalo State College, Buffalo, NY, 14222; [2]Geology Department, Middlebury College, Middlebury, VT, ^05753.
Hydrodynamics and Sedimentation Processes in the Buffalo River.

The International Joint Commission classified 43 rivers and harbors in the Great Lakes basin as Areas of Concern (AOCs), including the lower 9.2 km of the Buffalo River, because of environmental degradation due to contamination. The Buffalo River is influenced by a Lake Erie driven flow regime related to wind-generated surges and seiches that pile water at the eastern end of the lake. During low flow periods in the Buffalo River, lake waters can enter the river resulting in flow reversals. In order to understand more fully the magnitude and behavior of seiches within the river, horizontal and vertical Acoustic Doppler Current Profilers (ADCP), temperature and meteorological stations have been deployed at five sites located between the river mouth and the upper end of the AoC. Preliminary findings show a river oscillation with a period of 1.8 − 2.0 hours and winter flood events with speeds as high as 232 cm/s. ADCP data show the influence of such lake incursions for at least 4 − 5 km, reaching a stretch of the river where sedimentary furrows are present. Our work demonstrates the utility of empirical data derived from current, geophysical and sediment analyses to inform river restoration planning and monitoring efforts. *Keywords: Water currents, Hydrodynamics, Hydroacoustics.*

SMITH, D.E.[1], TWISS, M.R.[1], WILHELM, S.W.[2], BOURBONNIERE, R.A.[3], BULLERJAHN, G.S.[4], CARRICK, H.J.[5], and MCKAY, R.M.L.[4], [1]Department of Biology, Clarkson University, Potsdam, NY, 13699; [2]Department of Microbioloy, The University of Tennessee, Knoxville, TN,

37996; [3]Environment Canada / WS&T/ NWRI, Canada Centre for Inland Waters, Burlinghton, ON, L7R 4A6; [4]Department of Biological Science, Bowling Green State University, Bowling Green, OH, 43403; [5]School of Forest Resources, Pennsylvania State University, University Park, PA, 16802.
Tight Coupling of Phytoplankton Growth and Grazing Rates under Ice in Lake Erie.

In the winter, Lake Erie is characterized by a heterogeneous distribution of phytoplankton in both open water areas and below complete ice cover (see McKay et al. abstract, this conference). The phytoplankton community is dominated by species of the filamentous centric diatom *Aulacoseira*. We measured growth and grazing rates of phytoplankton using the Landry & Hassett (1982) dilution assay technique on water sampled in February 2008 and 2009. Assays (24-36 h) were conducted in incubators onboard the ship. Total Chl *a* at pelagic stations ranged from 0.44 to 4.38 µg/L. Size fractionated distributions of Chl *a* were (mean% ± SD, n = 7) microplankton (>20 µm) 41 ± 27%, nanoplankton (2-20 µm) 36 ± 12%, and picoplankton (0.2-2 µm) 23 ± 20%; stations with elevated total Chl *a* (>3.6 µg/L) were dominated by microplankton (66 to 82%). Size fractionated growth (µ) and grazing (g) rates (per day) were similar: microplankton µ = 0.85 ± 0.28, g = 0.83 ± 0.31; nanoplankton µ = 0.63 ± 0.35, g = 0.83 ± 0.55; picoplankton µ = 1.34 ± 0.80, g = 1.67 ± 1.77. These results leave open an explanation for high accumulations of Chl *a* in areas throughout the lake. *Keywords: Ice, Phytoplankton, Zooplankton.*

SMITH, G.J.[1], COOKE, S.[1], and HOWELL, T.[2], [1]400 Clyde Road, Cambridge, ON, N1R 5W6; [2]125 Resources Rd, Etobicoke, ON, M9P 3V6.
New Approaches to Developing Detailed Terrain Data for Watershed Nonpoint Source Modeling.

The inherent linkage between a watershed and a creek, river or lake is the form and function of its terrain. Characterizing that terrain through digital elevation models and improved stream drainage networks enables resource managers to make more informed decisions, specifically on the delivery of nutrients from non-point sources. Further, spring and summer rainfall events tend to drive the delivery of non-point sources of nutrients from the terrain within a watershed to the nearshore area of Lake Erie which, more recently, is causing a resurgence of Cladophora growth and subsequent impacts on water quality. A study, funded by the Canada-Ontario Agreement, in partnership with the Ministry of the Environment, to seasonally characterize water quality in three moderate-sized watersheds draining the central Lake Erie basin provided the opportunity to develop new approaches using aerial photography, 3D-mapping and radar data on rainfall to create detailed geospatial information. This presentation will examine how enhanced information will further our understanding of the interaction of precipitation with the terrain, the hydrologic network and its eventual impact on the creek systems and Lake Erie by helping to identifying priority areas for implementing land management practices to reduce the delivery of nutrients to Lake Erie. *Keywords: GIS, Watershed modeling, Spatial analysis, Cladophora.*

SMITH, G.J. and ACKERMAN, J.D., Department of Integrative Biology, University of Guelph, Guelph, ON, N1G 2W1. **Exploring the spatial and temporal patterns of hypoxia in the Central Basin of Lake Erie.**

Large-scale reductions in nutrient loading in Lake Erie has reduced eutrophication in the western basin but has not eliminated hypoxia in the Central Basin, where summertime dissolved oxygen (DO) levels can be hypoxic (DO < 4 mg/L) in the hypolimnion. In order to address the continuing issue of hypoxia it is critical to understand the spatial and temporal patterns in Lake Erie. We examined water column properties in 2008 and 2009 along a ~40 km west-east transect of stations in the western portion of the Central Basin where depths increased from 11.4 m to 20 m in the east. Stations were monitored using moored instrument arrays (DO, currents, temperature, turbidity). Water quality cruises were used to profile conditions relative to the lake bottom. Hypoxic events were observed over the 40 km transect up to ~3 m above the bottom (ab) in the west and 5 – 7 m ab in the east. These lasted for 2 to > 6 weeks depending on location. The near bottom DO levels were lower in 2009, as was the depth of the thermocline (smaller hypolimnion). These results will be used to evaluate three hypotheses to explain hypoxia in the central basin of Lake Erie. *Keywords: Water quality, Oxygen, Lake Erie.*

SMITH, I.R., 2 St. Clair Avenue West, 8th Floor, Toronto, ON, M4V 1L5, Canada. **Protecting The Great Lakes as Sources of Drinking Water through the Ontario Clean Water Act, 2006.**

Most persons living in Ontario get their drinking water from the Great Lakes – the vast majority from within the Great Lakes basin. The Clean Water Act, 2006 has started a process whereby communities are able to protect the quality and quantity of their municipal drinking water supplies through developing collaborative, locally driven, science-based source protection plans. These plans are developed by multi-stakeholder committees who are challenged to evaluate the science documenting vulnerable areas for water supplies, impacts in raw water, and threats to that water, and then to develop consensus on what measures are needed to (in some cases) restore water supplies and in all cases protect it. A specific focus of the protection of the Great Lakes enables collaboration across multiple areas and committees and the consideration of Great Lakes Agreements. Specific authorities in the Act for the Minister of the Environment enable the Minster to set targets for and across contributing watersheds to bridge the ability of the local plans to address threats and issues. The Clean Water Act is unique in that it puts in place a multi-tiered protection system that recognizes the importance of the Great Lakes as the primary source of drinking water for Ontarians. *Keywords: Great Lakes basin, Source Protection, Watersheds, Drinking water.*

SMITH, L.A. and CHOW-FRASER, P., Biology Department, McMaster University, Hamilton, ON, L8S 4K1, Canada. **URBAN – Urban-Rural Bio-monitoring and Assessment Network: A citizen science biological monitoring program for the city of Hamilton, Ontario.**

URBAN is a long-term citizen science program developed in collaboration with the Bay Area Restoration Council (BARC) and the Royal Botanical Gardens (RBG) to track changes in

biodiversity and ecosystem health in the Hamilton, Ontario region. This program will provide valuable ecological information on water quality, air quality, wetland health and forest health for conservationists, city planners, resource managers, and researchers while at the same time educating citizens on the eco-services these natural resources provide. We will develop a training manual containing standardized monitoring protocols for wetland plants, wetland birds, salamanders, earthworms, permanent forest plots, and lichens that are both easy to understand and educational. We will also develop a fully interactive website including volunteer training modules and self-administered tests along with data entry capabilities and the generation of long-term trend graphs (http://www.urbanmonitoring.ca). It is a pivotal time in the history of the planet because we have just recently been classified as an urban species. Even though concentrating people in urban centres is a solution to urban sprawl, we need to understand the impacts of urbanization on biodiversity of natural areas, and we must do this with the people who live in the city. *Keywords: Education, Monitoring, Biodiversity.*

SMITH, L.A. and CHOW-FRASER, P., Biology Department, McMaster University, Hamilton, ON, L8S 4K1, Canada. **The influence of wetland area and surrounding land use on bird communities in southern Ontario coastal marshes.**

Land transformations, specifically through urbanization, are considered to be the most important factor contributing to species extinction rates this century. Concern over the decline in many wetland-dependent bird species has led to increased monitoring of marsh bird populations in response to anthropogenic activities. We conducted point counts at 18 coastal wetlands in the Laurentian Great Lakes Region from 2006-2008 to determine the influence of wetland area and surrounding land use on marsh bird communities. We found a positive species-area relationship for wetland birds and also evidence of a positive relationship between the Index of Marsh Bird Community Integrity (IMBCI) and wetland area. Obligate marsh-nesting birds preferred rural over urban wetlands, while generalist marsh-nesting birds showed no preference. The IMBCI was significantly higher in rural compared to urban wetlands. Based on these results, we suggest limiting urban development within 1 km of the wetland edge, and the preservation of both large and small marshes as both contain species of high integrity. It is our hope that the current wetlands in southern Ontario will remain undisturbed through the development and implementation of policy, future research, and monitoring for early detection of changes and potential threats to these ecosystems. *Keywords: Urbanization, Avian ecology, Wetlands.*

SMITH, P.G.R., Ontario Ministry of Agriculture, Food and Rural Affairs, 1 Stone Road West, Guelph, ON, N1G 4Y2. **Agriculture in the Canadian Great Lakes Basin: How is it Changing and What is the Effect?**

Agriculture is a major land use in the Ontario portion of the Great Lakes basin and has substantial environmental effect, recognized since the PLUARG studies of the 1970s. But how is agriculture changing in Ontario? And what do changes mean for environmental effects? The PLUARG studies made predictions about change in agricultural land use and this informed management actions. Using a 1921-2006 time series of the Agricultural Census and compilation of agricultural census data by Lake basin, trends are examined in agricultural land use. The

period since the PLUARG reports has seen increases in land devoted to soybeans, wheat, vegetables and greenhouses, as well as growth in the numbers of chickens, hogs and sheep. On the other hand decreases have occurred in area of farmland, corn for silage, pasture, oats and flax, as well as in the numbers of farms and cattle. Production methods and spatial distribution have also changed. These trends are compared with trends predicted by PLUARG reports. Agriculture production also differs significantly among the different lake and river basins. Differences in farm income, practices, major crops and livestock characteristics are illustrated. How these changes and differences may influence priorities for best management practices to address water quality issues is discussed. *Keywords: Policy making, Agriculture, Nutrients, Land use.*

SMYTH, E.R.B.[1], MCLAUGHLIN, R.L.[1], and KOOPS, M.A.[2], [1]Department of Integrative Biology, University of Guelph, Guelph, ON; [2]Great Lakes Laboratory for Fisheries and Aquatic Sciences, Department of Fisheries and Oceans, Burlington, ON. **A Decision Analysis Evaluating Management Options for the Dam on the Black Sturgeon River.**

This study is using decision analysis to quantify ecological and social trade-offs of management options for the dam on the Black Sturgeon River, Lake Superior ON. The invasion of the sea lamprey has led to the implementation of a binational control program relying on in-stream applications of chemicals, trapping, and barriers to reduce sea lamprey abundances. Barriers prevent maturing sea lamprey from accessing upstream spawning habitat but can also impede the migrations of native fishes. There is concern that the Black Sturgeon dam is impeding recovery of walleye and lake sturgeon in the area. Management options for the Black Sturgeon dam include complete dam removal, reconstruction of the dam, dam reconstruction with provisioning of selective fish passage, and dam relocation above habitat suitable for walleye and lake sturgeon spawning. Literature syntheses and stage-structured models of population dynamics have been combined to characterize key uncertainties associated with each management option and the trade-offs between sea lamprey control and recovery of walleye and lake sturgeon. Explicitly quantifying and communicating the trade-offs and projected outcomes for the management options is expected to help stakeholders reach a decision for the Black Sturgeon dam that is balanced, sound, and scientifically defensible. *Keywords: Decision making, Walleye, Computer models.*

SNODGRASS, W.J.[1], BOUCHARD, R.[2], DEWEY, R.[3], YERUBANDI, R.[4], BOOTY, W.[4], and THORPE, B.[5], [1]City of Toronto, Metro Hall, 55 John Street, 18th Floor, Toronto, ON, M5V3C6; [2]Regional Municipality of Peel, 10 Peel Centre Drive, Brampton, ON, L6T 4B9; [3]City of Toronto, Metro Hall, 55 John Street, 27th Floor, Toronto, M5V 3C6; [4]Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [5]Toronto and Region Conservation, 70 Canuck Avenue, Downsview, ON, M3K 2C5. **Application of Event Simulations to Support Development of Source Water Protection Plans for Lake Ontario Intakes.**

Evidence based scenarios are being piloted as a tool for addressing legislated mandates, under Ontario's Clean Water Act, 2006 for evaluating the risk to intakes which draw their water supply from Lake Ontario. An inventory of sources which could spill a substance of concern in

sufficient quantity to cause a risk to an intake has been initiated. Sources of concern include large petrochemical complexes, industrial complexes, electrical power stations, spills from ruptured sewers, overflows from wastewater treatment plants, and shipping near the intakes structure. Evidence of specific events, which caused spills which did or could have been a risk to intakes, form the initial foundation for constructing the scenarios. This paper will present results for 2 -3 on-going scenarios / constituents. The results of the analysis will be considered by Source Water Protection Committees in developing plans to ensure that the drinking wate supplies are protected. *Keywords: Legislation, Risks.*

SOLOMON, S.K. and CHOW-FRASER, P., 1280 Main Street West, Department of Biology, Life Science Building, Hamilton, ON, L8S 4K1, Canada. **Effect of Road Remediation Efforts on Freshwater Turtle Populations.**

Recent research has shown that roads fragment freshwater turtle habitats and can lead to barriers in genetic exchange, migration and dispersal. Turtle mortality from vehicle collisions disproportionately affects mature females, resulting in male-biased sex ratios in areas of high road density. Roads that are built through or in close proximity to wetlands are a significant source of mortality and the annual loss of adult turtles contribute to population declines. The Long Point Causeway, which separates Big Creek marsh from the bay, causes significant annual road mortalities to amphibians and reptiles, many of which are species of concern. Remediation efforts to decrease the impacts of roads on wildlife have largely focused on mammals or the use of temporary measures such as drift fence. Construction of culverts or ecopassages has been suggested as a permanent mitigation measure that allow for the passage of wildlife underneath the road. There is a current proposal to construct a series of culverts along the Long Point Causeway to restore connectivity between the marsh and the bay. This presentation outlines a before-and-after survey of turtle populations which can be used to determine the effectiveness of this restoration strategy on reducing road mortality. *Keywords: Lake Erie, Remediation, Wetlands.*

SONEKAN, C. [1], BOEGMAN, L. [1] and YERUBANDI, R. [2], [1]Civil Engineering, Queen's University, Kingston, ON, Canada; [2]National Water Research Institute, Environment Canada, Burlington, ON, Canada. **Application of a one-dimensional hydrodynamic model to Hamilton Harbour and Lake Simcoe.**

Hamilton Harbour and Lake Simcoe are aquatic systems with Remedial Action Plans (RAP) to improve water quality. To assist with RAP planning and management, the one-dimensional hydrodynamic model, DYRESM was applied to simulate the vertical temperature structure in these systems during the ice-free season. For Hamilton Harbor, model evaluation was made with daily field data for the years 2003, 2004 and 2006. For Lake Simcoe, fortnightly field data from 2000 to 2003 was used for validation. Model skill was determined by calculating daily basin-average and depth-profile root mean square errors (rmse). For Hamilton Harbor, the daily rmse for all years ranged from 0.02 to 0.45°C, and the depth profiles of rmse had a minimum of 0.1 and a maximum of 3.8°C. In Lake Simcoe, preliminary simulations yield daily rmse within the range of 0.2 to 3.4°C, while the depth profiles of rmse had values from 0.7 to 3.6°C for all years.

Low rmse values in the epilimnion and hypolimnion suggest that the model effectively captures basin-averaged vertical hydrodynamics and heat storage, with errors in the thermocline likely resulting from the models inability to resolve horizontal dynamics (e.g. internal waves and upwelling/downwelling events). Results indicate model can extend to simulate water quality dynamics and assess climate change impacts. *Keywords: Hydrodynamic model*

SORGE, S., GUZZO, T.M., HAFFNER, G.D., FISK, A.T., and DROUILLARD, K.G., 401 Sunset Ave, Windsor, ON, N9B 3P4, Canada. **Examining spatial and temporal variation in polychlorinated biphenyl trophodynamics in the Detroit River and Lake Erie.**

Trends in polychlorinated biphenyl (PCB) trophodynamics of food webs from the Detroit River and Lake Erie from 1991-2009 were quantified to determine the extent of spatial and temporal variability. Samples were collected at Peche Island in the upper Detroit River and Middle Sister Island located in central Western Basin of Lake Erie. Species were collected representing major trophic levels, including benthos, forage fish, mixed feeders, piscivores and benthic fish. PCB variability was observed to decrease with increasing trophic level across sites, for example, piscivores showed lower spatial and temporal variability than forage fish. PCB concentrations also varied between sites, as forage fish at Middle Sister Island (Emerald Shiner PCB 153- 321 ng/g lipid) had higher concentrations than those of Peche Island (Emerald Shiner PCB 153- 198 ng/g lipid). Overall PCB concentrations exhibited no change in concentration within sites over the duration of the study. These data suggest that individual variability in PCB concentrations within Detroit River and Western Lake Erie food webs are dependent on the trophic characteristics of the species. Thus, a food web approach is required to quantify small and large scale variability of PCB dynamics in aquatic ecosystems. *Keywords: Trophic level, Environmental contaminants, PCBs.*

SOWA, S.P., DORAN, P., KHOURY, M., and HERBERT, M., 101 E. Grand River, Lansing, MI, 48906. **The Nature Conservancy's Perspective, Approach and Application of Conservation Planning in the Laurentian Great Lakes.**

Conservation planning is critical to successful conservation. However, it is also a very broad and complex topic. Considering the multifaceted and multiscale nature of conservation planning it is not surprising that this topic can lead to confusion even among conservationists. The Nature Conservancy, recognizing the many components of conservation planning, has developed an overarching strategy, known as Conservation By Design, that seeks to integrate these many interrelated and essential components into a comprehensive and efficient planning approach. Conservation by Design provides an integrated approach that establishes conservation goals, guides actions, and directs resources to gain the greatest conservation results. It is an iterative and adaptive approach that operates at multiple scales, from local to global, and has been successfully employed in a diversity of geographic and cultural settings, including the Great Lakes. The presentation will include discussion of the basic concepts of Conservation by Design as reflected in each of three key analytical methods, namely Major Habitat Assessment, Ecoregional Assessment and Conservation Action Planning. *Keywords: Conservation, Laurentian, Planning, Great Lakes, Biodiversity.*

SPENCE, C.[1], BLANKEN, P.D.[2], HEDSTROM, N.[1], FORTIN, V.[3], and HAYWOOD, H.[1], [1]Environment Canada, 11 Innovation Blvd, Saskatoon, SK, S7N 3H5; [2]University of Colorado, Boulder, CO, 80309-0260; [3]Environment Canada, 2121 TransCanada Highway, Dorval, QC, H9P 1J3. **Evaporation from Lake Superior.**

There are ongoing concerns over the socioeconomic and ecological impacts of a sustained period of low water levels in Lakes Superior, Michigan and Huron that began in the late 1990's. Recent low water levels may be due to larger evaporation rates. There is no doubt that evaporation is a critical component of the annual water balance of the Laurentian Great Lakes but uncertainty in current operational evaporation estimates is relatively high. Perhaps surprisingly, almost nothing is known about evaporation dynamics from Lake Superior, and few direct measurements of evaporation have been made from any of the Laurentian Great Lakes. This research is the first to attempt to directly measure evaporation from Lake Superior by deploying eddy covariance instrumentation at the Stannard Rock lighthouse. Evaporation rates, their patterns, and controlling mechanisms will be presented. Seasonal differences will be discussed. The direct measurements of evaporation were used to construct empirical equations that with concurrent climate model data were used to extrapolate evaporation measurements across the entire lake. This knowledge could improve predictions of how climate change and variability may impact the lake's water budget and subsequently how the water in the lake is managed. *Keywords: Atmosphere-lake interaction, Evaporation, Water level fluctuations, Lake Superior.*

SPRULES, W.G., Department of Biology, University of Toronto, Mississauga, ON, L5L 1C6, Canada. **Spatial Patterns of Freshwater Zooplankton in Nearshore Regions of Varying Wind Exposure and Bottom Slope.**

While large-scale, wind-driven spatial distributions of lake zooplankton are reasonably well studied, much less is known about smaller-scale patterns in nearshore zones where physical processes can be complex. In low productivity lakes onshore movement of water masses may lead to sediment resuspension that could supplement food web productivity if organisms can spatially orient to such localized events. I measured nearshore spatial patterns of zooplankton with an Optical Plankton Counter in mesotrophic Lake Opeongo, Ontario under a variety of wind conditions, bottom slope, and proximity to the shore. Some transects ran perpendicular to the shoreline along both shallow and steep slopes while others ran parallel to shore at distances above and below water depths where sediments contacted warm epilimnetic water. Preliminary results do not show strong relationships between transect slope or orientation for all zooplankton combined. However there were marked differences in small- versus large-bodied zooplankton with the latter generally showing stronger spatial patterns at both the small (meters) and large (hundreds of meters) scale, particularly when the wind force was weak. These results suggest that larger-bodied animals may be more able to take advantage of local "hotspots" of productivity. *Keywords: Spatial analysis, Zooplankton, Littoral zone.*

ST JOHN, M.A. and BACH, C., Toronto and Region Conservation Authority, 5 Shoreham Dr, Downsview, ON, M3N 1S4. **The Implementation of the Toronto Waterfront Aquatic Habitat Restoration Strategy – A Novel Approach to Managing the Aquatic Habitat of the Toronto Waterfront.**

Historic degradation of the shoreline of the Greater Toronto Area led to substantive loss of aquatic habitat. Interest in revitalizing the waterfront has recently emerged, resulting in the creation of the Toronto Waterfront Aquatic Habitat Restoration Strategy. To ensure that projects associated with this restoration strategy are implemented in a timely and cost efficient method Aquatic Habitat Toronto (AHT) was formed. AHT consists of representatives from federal, provincial and municipal government organizations. This presentation will showcase the planning process undertaken by AHT involving consensus based development of aquatic habitat on the Toronto Waterfront. We will provide an overview of the research, monitoring, planning and implementation of restoration projects with respect to aquatic habitat to date. The Toronto Waterfront Aquatic Habitat Restoration Strategy represents an integrated approach to adaptive management. The strategy is an effective tool for facilitating federal, provincial and municipal agencies in their respective review and approval process ensuring a sustainable policy 'no net loss' of fish habitat for development on the waterfront. *Keywords: Biomonitoring, Fish management, Lake Ontario.*

STAINSBY, E.A.[1] and SCHMARJE, E.[2], [1]Ministry of the Environment, 125 Resources Road, Etobicoke, ON, M9P 3V6; [2]Ministry of the Environment, 55 St. Clair West, Toronto, ON, M4V 2Y7. **A Phosphorus Reduction Strategy for Lake Simcoe.**

The Lake Simcoe Protection Plan, released by the Province of Ontario on June 2, 2009, is a comprehensive plan designed to protect and restore the ecological health of Lake Simcoe and its watershed. One of the commitments of the Plan is the reduction of phosphorus to achieve a dissolved oxygen target of 7 mg/L to promote a self-sustaining coldwater fish community and improve water quality in Lake Simcoe. Based on our best available science this translates to a phosphorus load to the lake of 44 tonnes/yr, a reduction of almost 40% from the current five-year average load of 72 tonnes/yr. To achieve the ambitious reductions in phosphorus loadings, there would need to be reduced loadings from all sources that contribute to excess phosphorus throughout the watershed. The Plan supports a coordinated, adaptive management, and phased approach to reducing excess phosphorus through the development of a Phosphorus Reduction Strategy for the Lake Simcoe watershed. The Strategy identifies practical and effective actions that to be taken to reduce phosphorus from each source or sector that contributes phosphorus load to the watershed. *Keywords: Lake Simcoe, Ecosystem health, Environmental policy, Phosphorus.*

STAINTON, M.P.[1], MCCULLOUGH, G.K.[2], and PAGE, S.J.[1], [1]Department of Fisheries and Oceans, 501 University Crescent, Winnipeg, Mb, R3T 2N6; [2]Department. of Earth Observation Science, Department of Environment and Geography, University of Manitoba, Winnipeg, Mb, R3T 2N2. **A Lake Winnipeg Carbon Budget.**

A carbon budget for Lake Winnipeg is presented. Measurements of riverine inflow/outflow, atmospheric gas exchange, photosynthesis/respiration and sediment records are used to construct a carbon budget for Lake Winnipeg that reflects recent increases in algal productivity. Discussion will link the carbon budget to recent changes in phosphorous loading to the lake. *Keywords: Carbon, Productivity, Eutrophication.*

STANFIELD, L.W., GAIOT, J.S., and STROBL, S.I., Ontario Ministry of Natural Resources, 300 Water Street, Peterborough, ON, K9J 8M5.
Improving understanding of tributary influences on the Great Lakes: Improved linkages between field and geospatial datasets in Ontario.

Environmental modeling of the influence of the landscape on ecosystems, at all scales of analysis, requires a basic linkage between geospatially referenced tabular field data and various mapped datasets. Conducting analysis that is meaningful across the Great Lakes requires large datasets of unique records that can only be obtained through the compilation of datasets from a variety of sources. Recent attempts to compile such datasets have identified some fundamental challenges that have to date largely prevented a broad scale analysis of Great Lakes tributary conditions from being conducted. In this paper we present several new tools and datasets that will provide the foundation to enable the compilation of uniquely identifiable site data across the landscape. We will introduce a new unique waterbody identification coding system that describes in tabular and spatial format the unique location of a sample site. We will introduce a new flowing waters information system to assist with the management and sharing of field data and that provides a mechanism for verifying the uniqueness of and the correct location of field sample sites. Finally we will provide a vision for how flowing waters monitoring can be better integrated and managed across the Great Lakes Basin. *Keywords: Data storage and retrieval, Tributaries, Monitoring.*

STANG, C.M.[1], GHARABAGHI, B.[1], RUDRA, R.P.[1], SHERMAN, K.[2], WALTERS, M.[3], and PALMER, R.M.[4], [1]50 Stone Road East, Guelph, ON, N1G 2W1; [2]67 Fourth Street, Midland, ON, L4R 3S9; [3]120 Bayview Parkway, Newmarket, ON, L3Y 4X1; [4]120 Hume Street, Collingwood, ON, L9Y 1V5.
Use of Agricultural Best-Management Practices for Watershed Management.

Severn Sound (i.e. southeastern Georgian Bay) experienced eutrophic conditions and excessive algae production causing it to be listed as an Area of Concern on the Great Lakes. In 2002, Severn Sound became delisted after the successful implementation of numerous agricultural Best Management Practices (BMPs) aimed at reducing non-point source watershed loadings of sediment and sediment-bound phosphorus. The aim of this study was to evaluate the effectiveness of the applied agricultural BMPs in reducing sediment and phosphorus loads into Georgian Bay. Instantaneous grab samples analyzed for Total Suspended Solids (TSS) and Total Phosphorus (TP) and continuous streamflow data were taken at the watershed outlets of Hog Creek and Sturgeon River. Techniques for estimating sediment yields between sampling intervals and aggregated to monthly and annual loads reflected the periods before and after the implementation of BMPs and BMP reduction factors found in literature. The BMP reduction

factors were further evaluated by simulating watershed-based loadings of nutrients, sediment and streamflow with the CAnadian Nutrient and Water Evaluation Tool (CANWET). The model was able to accurately simulate the temporal variability of sediment and nutrient loads from the two case study watersheds for different phases of BMP implementation. *Keywords: Water quality, Watershed Modeling, Sediment transport, Best Management Practices, Nutrients, Severn Sound.*

STAPLES, J.[1] and PFEIFFER, S.[2], [1]300 Water Street, 5th floor - Water Resources Section, Peterborough, ON, K9J8M5; [2]Wisconsin Department of Natural Resources, PO Box 7921, 101 South Webster Street, Madison, WI, 53707. **Water Quantity and Ecological Impact Assessment in Wisconsin.**

Wisconsin passed implementing legislation for the Great Lakes Compact in 2008 and is currently revisiting its groundwater quantity legislation. Both of these pieces of legislation address the issue of ecological impacts of water withdrawals. The Wisconsin Department of Natural Resources is currently exploring how to assess the biological impact of water withdrawals in its management program. This presentation will provide an overview of Wisconsin's relevant legislation, current process for identifying a mechanism to manage water withdrawal with respect to assessing ecological impact, and relevant data availability and needs. *Keywords: Watersheds, Ground water, Water level, Great Lakes basin.*

STASTNA, M., Department of Applied Mathematics, University of Waterloo, 200 University Ave. West, Waterloo, ON, N2L 3G1. **Simulating Internal wave dynamics using high order methods.**

The interior of temperature stratified lakes is dynamically active on many different length scales. Internal waves occupy a wide range of length scales and have been documented as influencing both mixing in the interior of the water column and resuspension from the lake bottom. In this talk I will review two different approaches to the numerical modeling of internal waves: 1) two dimensional motions of continuously stratified fluids, 2) multi layer models. I will discuss the challenges this modeling presents, especially due to the inherently dissipative nature of many standard numerical models and will report on progress toward the development of software based on high order methods. I will use boundary layer instability leading to sediment resuspension and the interaction of internal waves with simple models of plankton dynamics as example problems to illustrate the strengths and weaknesses of the new models. *Keywords: Waves, Internal waves, Sediment resuspension, Zooplankton.*

STEPIEN, C.A. and BROWN, J.E., Lake Erie Center and Dept. Environmental Sci., 6200 Bayshore Road, Toledo, OH, 43616. **Population Genetic History of the Dreissenid Mussel Invasion: Expansion Patterns Across North America.**

We analyze genetic patterns across the Eurasian dreissenid mussel invasion of North America, with 9 nuclear microsatellite loci for 583 zebra (21 sites) and 269 quagga mussels (12 sites) from native and invasive populations, including the Great Lakes, Mississippi River basin,

Atlantic coastal waterways, Colorado River system, and California reservoirs. Results indicate that zebra mussels originated from multiple non-native northern European populations, whereas quagga mussels trace to native Southern Bug and Dnieper River estuaries. Invasive populations show considerable genetic diversity and structure, with few founder effects (the exception being new western populations of the quagga mussel). Their genetic compositions changed over time at given sites; with some adding alleles from adjacent populations, some losing them, and all retaining closest similarity to their original composition. Western populations assign to the eastern Great Lakes, suggesting that overland colonization pathways via recreational boats do not necessarily reflect the most proximate connections. In conclusion, our microsatellite results comprise a valuable baseline for resolving present and future dreissenid mussel invasion pathways. *Keywords: Dreissena, Quagga mussel, Genetics, Zebra mussel, Invasive species, Invasion pathways.*

STEWART, K.M., Dept. Biological Sci., State University of New York, Buffalo, NY, 14260, USA. **Increasing Dominance of "quagga" mussels in the Erie Canal.**

There is an increasing dominance of *Dreissena bugensis* "quagga" mussels at numerous sites along the Buffalo-Syracuse portion of the Erie Canal. Sampling for *D. polymorpha* and *D. bugensis* was undertaken at two sites in 1991, expanded to 20 sites in the winter of 1993, and continued (temporally) unevenly at up to 21 sites until the winter of 2009. The majority of collections were made in the winter (usually Feb) through the ice of the mostly frozen Canal. In winter, in part of the Buffalo-Syracuse section (specifically the Lockport-Fairport section), the water level is lowered from its usual depth of ~ 3.6 m down to < 1/2 m, but there is still some easterly flow of water. The collections themselves can range from being simple to very challenging (risky, bad ice) and time-consuming. The extended collection effort (multiple sites over many years shows the relative rapidity with which quaggas go from a few % to nearly 100% of the dreissenids collected. Interestingly, although the quaggas have spread (west to east) fairly rapidly, their distribution is not uniform along the Canal. *Keywords: Dreissena, Invasive species, Erie Canal, Zebra mussels.*

STEWART, R.M., NICHOLSON, A.A., and ADAMS, M.A., Department of Geography, Lakehead University, 955 Oliver Road, Thunder Bay, ON, P7B 5E1. **Challenges on the Road to Delisting Great Lake's Areas of Concern: Case studies from the North Shore of Lake Superior.**

This paper explores challenges in the Great Lakes Remedial Action Planning (RAP) process as they relate to a transition from the design of remediation strategies to the delisting of an Area of Concern (AOC). These challenges are illustrated based on research done in four case studies along the North Shore of Lake Superior: Thunder Bay; Nipigon Bay; Jackfish Bay, and; Peninsula Harbour. Since the establishment of these AOCs in the 1980s, RAP teams have successfully identified ecological impairments, created and implemented a plan of remedial action, and are now in the process of assessing remedial success as it relates to ecosystem recovery and the ability to achieve specific delisting criteria. Although the final phase of the RAP process is underway, there are key challenges that exist that deserve immediate attention.

This paper highlights these challenges as they pertain to: 1. Assessing the current status of ecosystem impairment; 2. Monitoring future ecosystem recovery; 3. Overcoming governance, policy and process issues, and; 4. Community capacity and socio-economic issues unique to each AOC. The paper concludes with key considerations and management recommendations that could reduce these challenges and enhance the ability of RAP teams to successfully meet delisting criteria. *Keywords: Lake Superior, Area of Concern, Ecosystem health.*

STEWART, T.J.[1] and SPRULES, W.G.[2], [1]Ontario Ministry of Natural Resources, Lake Ontario Managment Unit RR # 4, Picton, ON, K0K 2T0, CANADA; [2]University of Toronto, Department of Ecology and Evoluitonary Biology, Mississauga, ON, L5L 1C6, CANADA. **The offshore Lake Ontario food web before and after invasion-associated ecosystem change with an emphasis on Mysis trophic interactions.**

We develop mass-balanced solutions describing carbon-based trophic structures and flows of the Lake Ontario offshore food web before (1987-1991) and after (2001-2005) invasion-associated ecosystem change. The food webs include 19 species-groups and three detrital groups. Mass-balance was achieved by randomly varying initial determinations of biomass and diet. Primary production declined as did the biomass and production of all species-groups except Chinook salmon. The trophic level increased for all prey fish, largely due to increased consumption of Mysis. Examination of changes in carbon flow among species-groups suggest top-down influences of zooplankton on bacteria and protozoa, alewife on zooplankton and Mysis, and Mysis on zooplankton and Diporeia. Mysis are shown to be trophically linked to all major pathways of energy flow. Mysis rivaled alewife as a consumer of all zooplankton groups. Mysis were significant predators on Diporeia, and with the decline in other Diporeia predators (smelt and sculpin), became increasingly dominant. Despite the very low and declining estimated occurrence of Diporeia in Mysis diets (1-3%), Mysis were estimated to consume 20% of total annual Diporeia production in 1987-1991, increasing to 33% in 2001-2005. We hypothesize that Mysis may have had a role in the recent decline of Diporeia. *Keywords: Ecosystem modeling, Biological invasions, Lake Ontario.*

STEWART, T.J.[1] and SPRULES, W.G.[2], [1]Ontario Ministry of Natural Resources, Lake Ontario Management Unit RR # 4, Picton, ON, K0K 2T0, CANADA; [2]University of Toronto, Deparment of Biology, Mississauga, ON, L5L 1C6, CANADA. **Simulation of the Trophic Consequences of Bloater (*Coregonus hoyi*) Reestablishment in Lake Ontario Before and After Invasion-Induced Ecosystem Change.**

We simulate the reestablishment of bloater (Coregonus hoyi) in Lake Ontario, by deriving mass-balanced descriptions of the offshore food web, that include bloater, before (1987-1991) and after (2001-2005) invasion-induced ecosystem change. We base our simulations on observed levels of coexisting biomass stanzas of Lake Michigan alewife and bloater and associated predator and prey diets. Our simulations suggest that bloater could be sustained in Lake Ontario, at approximately 12% of the combined total alewife and bloater biomass. At these low levels of bloater biomass, the intensity of predation on Diporeia, other benthos, and Mysis increased, but was unchanged for other prey groups. At higher levels of bloater biomass,

estimates of predation loss exceeded prey production by factors of 3.2 to 10.6 for Diporeia and by factors of 1.5 to 3.0 for Mysis. Our simulations indicate that reestablished bloater would replace alewife as the dominant consumer of Mysis and replace adult sculpin and Mysis as the dominant consumers of Diporeia. The simulations suggest that bloater production in Lake Ontario would be limited by low Diporeia production. The shifts in feeding relationships among alewife, bloater, Mysis and Diporeia required to balance the food webs, indicated important and complex feeding interactions among these species. *Keywords: Fish management, Model studies, Invasive species.*

STILLE, J., TONINGER, R., and MACPHERSON, G., 5 Shoreham Drive, Downsview, On, M3N 1S4. **Restoration Opportunities Planning in the GTA – New Technique for Implementation Planning on a Watershed Basis Utilizing Hydrology, Topography, and Natural Cover Parameters.**

Toronto and Region Conservation Authority (TRCA) is one of the leading agencies for ecological restoration in the Greater Toronto Area. Past restoration planning has had a terrestrial emphasis lacking a complete picture of hydrology. In order to effectively meet natural cover targets across the watershed, TRCA has created a process utilizing desktop and field techniques to identify and prioritize restoration opportunities on a hydrologic basis. The approach is rooted in an understanding of topography and drainage to delineate and prioritize restoration opportunities (wetland, riparian and forest) which are then verified in the field. Using GIS, catchment boundaries and drainage lines can be derived. The catchments can be overlaid onto other GIS information layers (wetland, forest, etc.). Summary statistics on percent cover within these catchments can be calculated and compared across a given watershed to prioritize areas for restoration and protection. Using the drainage lines, assessors can determine the intermittent and permanent flow of water, as well as depressions on the landscape for riparian or wetland restoration projects. Armed with the desktop information, restoration opportunities are identified in the field across a given watershed. Resources are then allocated to restore and protect high priority areas. *Keywords: Watersheds, Prioirtization, GIS, Restoration, Decision making.*

STINSON, G.[1], PATEL, M.[1], BOWERING, T.[1], and DEWEY, R.[2], [1]City of Toronto, Metro Hall, Station 1180, 55 John Street, 18th Floor, Toronto, ON, M5V3C6; [2]City of Toronto, Metro Hall, 55 John Street, 27th Floor, Toronto, ON, M5V 3C6. **Trends in the Posting History of Toronto's Beaches for Past Two Decades.**

This paper analyses the trends in E Coli data for Toronto's beaches as a scientific support to delisting 'beach closures' as a 'beneficial use impairment (BUI)' for the Toronto AOC. Toronto has three types of beaches: those primarily impacted by direct discharges, those primarily impacted by major watershed discharges, and those which have no discharges nearby. Where stormsewer discharges have been managed, improvement in beach water quality has been significant, resulting in the main impacts being waterfowl/ waterbirds. As such residual impacts are of a chronic nature,it is proposed that the BUI for these beaches should be classifed as addressed and hence a candidate for delisting. *Keywords: Trends in E Coli.*

STOCKWELL, J.S.[1], YULE, D.L.[2], <u>HRABIK, T.R.</u>[3], and SIERSZEN, M.J.[4], [1]Gulf of Maine Research Institue, 350 Commercial Street,, Portland, ME, 4101; [2]USGS Great Lakes Science Center, 2800 Lake Shore Drive East, Ashland, WI, 54806; [3]University of Minnesota, Duluth, 207 Swenson Science Building, 1035 Kirby Drive, Duluth, MN, 55812; [4]Mid-Continent Ecology Division, 6201 Congdon Boulevard, Duluth, MN, 55804. **Cisco as an Energy Vector from Offshore Pelagic to Nearshore Benthic Habitats in Lake Superior.**

Cisco (Coregonus artedi) is a highly-mobile, planktivorous fish species in Lake Superior. Adults are found in the pelagia throughout the lake, but migrate to nearshore areas to spawn in November and December. Because cisco eggs do not hatch until the following spring, they represent a high-energy prey for the nearshore fish community during the winter months when prey resources are presumably scarce. As such, cisco may act as a critical energy vector linking offshore pelagic production to nearshore benthic fish communities. In this presentation, we synthesize data on cisco spawner abundance, fecundity, energy density, bioenergetics, and stable isotopes to 1) estimate the conversion efficiency of pelagic zooplankton resources to cisco gonads, 2) the amount of energy (in the form of cisco spawn) deposited in nearshore regions of western Lake Superior, and 3) the potential importance of this prey resource subsidy to the nearshore fish community. *Keywords: Acoustics, Coregonus artedi, Nearshore, Offshore.*

<u>STOW, C.A.</u>[1] and LAMON, E.C.[2], [1]noaa glerl, Ann Arbor, MI, 48108; [2]Statistical Ecology Associates LLC, Canyon Lake, TX, 78133. **Evaluating and Forecasting Lake Superior Water Level Fluctuations Using Dynamic Linear Models.**

Though there are many alternatives, researchers commonly use linear regression models to analyze time-series data and cite p-values to indicate the presence or absence of significant trends. As an alternative we used Dynamic Linear Models (DLM) to analyze annual average Lake Superior water levels from 1860 to 2007. Our results indicate strong evidence favoring the presence of a systematic trend over a random walk, and this trend has been negative in recent decades. We show evidence favoring a model in which the trend component is replaced with regression components consisting of climatic drivers as predictor variables. Because these models use lagged values of precipitation or net precipitation as predictors, the models can be used to forecast water levels, with the associated uncertainty, several years into the future. We use some of the best fit models and compare one (2008) and two step-ahead (2009) forecasts. Both the one step-ahead 2008 forecasts and the two step-ahead 2009 forecasts compare well with the observed values. The Bayesian context in which these models are developed provides a rigorous framework for data assimilation and regular model updating. Future work will include an assessment of the relative predictive capabilities of these simpler statistical models with more complex process-based models. *Keywords: Lake Superior, Bayesian, Water level fluctuations, Mathematical models.*

<u>STRUGER, J.</u>[1], SVERKO, E.[1], CAGAMPAN, S.[1], GRABUSKI, J.[1], MARVIN, C.[1], KRAFT, J.[1], and HESLIP, L.[2], [1]Environment Canada, Box 5050, Burlington, ON, L7R 4A6; [2]#905-3165 Russell St., Windsor, ON, N9C 4E1. **Pesticides in Surface Waters of Ontario.**

Pesticides are heavily used in agricultural production and in urban areas of southern Ontario. Since 2003, the Ontario Water Quality Monitoring and Surveillance Section of Environment Canada (EC) in Burlington has been sampling a number of surface water sites for a variety of current use pesticides. The program is part of a national initiative by EC and has evolved from sampling a standard suite of currently used pesticides such as neutral and acid herbicides and organophosphorous insecticides to now include pesticides such as sulfonyl urea and related herbicides, carbamate pesticides, glyphosate, imidacloprid and methoprene. This has allowed for the development of a surface water pesticide database with over 900 samples collected from over 80 locations in southern Ontario representing pesticide inputs from corn and soybean growing areas, fruit growing areas and areas influenced by urban activities. The most commonly detected pesticides include atrazine, metolachlor, dicamba, mecoprop, 2,4-D and diazinon. Many samples contained multiple detections of pesticides. These results will be discussed in relation to aquatic life guidelines, pesticide use information and implications for analytical methods development. *Keywords: Water quality, Great Lakes basin, Pesticides.*

STRUGER, J., RICHARDSON, V., and WATSON, S., Environment Canada, Box 5050, Burlington, ON, L7R 4A6. **Occurrence of Glyphosate and AMPA in Open Waters and Tributaries of Lake Erie.**

Application of the herbicide (GLY-P) has escalated in recent years with the widespread increase in corn and soybean production in the Great Lakes Basin. Previous environmental concerns with this herbicide focussed on ecotoxicological issues, but compelling evidence now suggests that GLY-P may have other, more pervasive effects contributing to the selective development of harmful algal blooms (HABs)in receiving waters. Research shows that the GLY-P breakdown product AMPA can be exclusively assimilated by some cyanobacteria as an alternative P source, providing a selective enhancement and competitive edge in algal communities. To address this issue GLY-P and AMPA were measured in the Lake Erie pelagic zone in major US and Canadian tributraies in 2008 and 2009 following spring application of the herbicide. Surface (1m) samples were collected from approximately 32 lake, river mouth and upstream stations. GLY-P and AMPA were primarily detected in the tributary and upstream stations and not at any pelagic stations. Maximum GLY-P and AMPA concentrations were 1.72 ug/L and 0.73 ug/L respectively, well below the Canadian Water Quality Guideline (65 ug/L)considered protexctive of aquatic life. Levels of AMPA were also significantly below those supporting in vitro cyanobacterial growth (~10uM or 1mg/L). *Keywords: Tributaries, Lake Erie, Glyphosate.*

STURTEVANT, R.A., NOAA Great Lakes Environmental Research Laboratory (GLERL), 4840 South State Road, Ann Arbor, MI, 48108. **GLANSIS as a Management Tool.**

The Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS - http://www.glerl.noaa.gov/res/Programs/ncrais/glansis.html) is a new information tool which can support the management of aquatic invasive species in the Great Lakes. This presentation will include an overview of recent enhancements to the system as well as those planned under GLRI

funding. Mechanisms for submitting sightings and receiving alerts via the USGS partnership will be highlighted along with a framework for usability in a management context or rapid response scenario. *Keywords: Invasive species, Data storage and retrieval, Management.*

STURTEVANT, R.A.[1] and DOMSKE, H.[2], [1]NOAA Sea Grant & COSEE Great Lakes, 4840 South State Road, Ann Arbor, MI, 48108; [2]New York Sea Grant, 204 Jarvis Hall, Buffalo, NY, 14260-4400.
School for Scientists: Evaluation of an IAGLR-COSEE partnership.

COSEE Great Lakes partnered with IAGLR in conducting a unique professional development opportunity "School for Scientists" at the 2007 and 2009 IAGLR conferences. These sessions provided training for scientists on how to better engage in educational outreach and were based on a needs assessment survey conducted of the IAGLR membership in 2006. Here we present the results of the formal program evaluation to the IAGLR members. *Keywords: Education, Great Lakes basin, Outreach.*

SULLIVAN, J.M. and BOYER, G.L., SUNY-College of Environmental Science and Forestry, Syracuse, NY, 13210.
Potential Discrimination of Phytoplankton Genera on the Basis of Their Pigment Fingerprints.

Cyanobacterial blooms in the Great Lakes are an emerging problem due to their production of neurotoxic and hepatotoxic compounds. To protect recreational and drinking waters, it would be beneficial to detect these organisms using *in situ* or autonomous techniques. Blooms of cyanobacteria can be discriminated from non-toxic green algal blooms by *in situ* fluorescence measurements (e.g. phycocyanin). However, it is more difficult to differentiate non-toxic cyanobacteria from toxic genera. Here we report on the use of carotenoid fingerprints as determined by high-performance liquid chromatography coupled with diode array detection (HPLC-DAD) and the use of a liquid waveguide capillary cell (LWCC) to separate potentially toxic genera from non-toxic species. HPLC-DAD analysis of *Microcystis* indicated that the major accessory pigments were β,β-carotene, echinenone, and zeaxanthin. These pigments provide a fingerprint which was different from those obtained for other genera. This information is being used in a 1 m LWCC flow cell coupled with a DAD detector and processed with a similarity index to determine the taxonomic resolution of these optical fingerprints. *Keywords: Cyanophyta, Algae, Species composition.*

SUN, Y.[1] and WELLS, M.G.[2], [1]Department of Geography, 100 St. George Street, Toronto, ON, M5S 3G3; [2]Department of Physical and Environmental Sciences, 1265 Military Trail, Toronto, ON, M1C1A4.
How the physical dispersion of ballast water influences the risk of aquatic invasive species establishment – field observations and modelling.

Ballast water discharge is held responsible for most of the successful invasions of non-indigenous species into the Great Lakes. The probability of post-discharge establishment of an alien species depends upon the rate at which the density of the population decreases due to physical dilution compared to the biological growth rate. Observations are presented from four

field experiments that measured the dispersion patterns of discharged dyed ballast water. These experiments were performed at two very different sites, the first in 2008 conducted at Goderich Harbour had a long hydraulic retention timescale, whereas a similar experiments in 2009 was conducted in the fast flowing St. Clair River. The very different flushing dynamics of these two locations are compared with the logistic population model with the Allee effect. We find that it is important to include a hydraulic "dead zone" in order to properly simulate the dilution properties of realistic water body. These "dead zones" are sites of lowered dilution ability, making it easier for successful establishment of introduced alien species. Therefore population dynamics of organisms discharged by ballast water are described using simple box models. Risk analyses are also compared with a range of different dilution rates that are relevant to harbours around the Great Lakes *Keywords: Ballast, Invasive species.*

SVERKO, E.[1], REINER, E.J.[2], HOMY, G.T.[3], MCCRINDLE, R.[4], SHEN, L.[2], ARSENAULT, G.[4], ZARUK, D.[1], MACPHERSON, K.A.[2], MARVIN, C.H.[1], HELM, P.A.[2], and MCCARRY, B.E.[5], [1]Environment Canada, Burlington; [2]Ontario Ministry of the Environment, Etobicoke; [3]Depratment of Fisheries and Oceans, Winnipeg; [4]Wellington Laboratories, Guelph; [5]McMaster University, Hamilton; [6]dsfgdf, dfgdfg.
Compounds Structurally Related to Dechlorane Plus in Sediment and Biota from Lake Ontario.

The historical occurrence of Dechlorane Plus (DP) and detection of novel compounds structurally related to DP is described in a dated Lake Ontario sediment core. Our core was collected near the mouth of the Niagara River which is known to be a major source of DP to the lake. Maximum DP concentrations (920 ng g-1, dry weight) were observed between 1976-1980; the highest reported to date. Following that time, we observed a dramatic decrease in DP concentration which coincided with the enactment of United States federal and state laws to mitigate free release of chemicals into the Niagara River and installation of an industrial wastewater treatment facility. During the course of our research, four new substances, structurally related to DP were also identified. These compounds were thought to arise from the Diels-Alder reactions resulting from impurities present in 1,5-cyclooctadiene, a feedstock used in production of DP. Further analysis revealed the presence of these novel compounds in the core. Interestingly, we also were able to identify a monoadduct compound in lake trout. The concentration of this monoadduct was approximately two orders of magnitude greater than that of DP suggesting suggesting that it is more bioaccumulative. *Keywords: Environmental contaminants, Bioaccumulation, Lake Ontario.*

TALEBAN, V.[1], GHARABAGHI, B.[1], WALTERS, M.[2], and WINTER, J.[3], [1]University of Guelph, School of Engineering, Guelph, ON, N1G 2W1; [2]Lake Simcoe Region Conservation Authority, Newmarket, ON, L3Y 4X1; [3]Ontario Ministry of the Environment, 125 Resources Road, Toronto, ON, M9P 3V6.
Wind Erosion Susceptibility Map for the Lake Simcoe Airshed.

One of the major sources of phosphorus to Lake Simcoe is atmospheric deposition, which is responsible for between 21% and 49% of the total phosphorus entering the Lake. This study aims to map the main local sources of atmospheric phosphorus to Lake Simcoe. Soil samples

taken from 21 sites around Lake Simcoe, including dominant agricultural soils, aggregate mining sites, active construction sites and unpaved roads have been tested for particle size distribution, soil texture classification and soil total phosphorus content. These soil samples have also been tested for potential dust emission rate for a range of wind speeds and soil moisture content using the Portable In-Situ Wind Erosion Laboratory (PI-SWERL) tests. The Wind Erosion Equation (WEQ) model developed by United States Department of Agriculture is used to calculate wind erosion rates for agricultural soils under dominant crop production and management systems in the region. Using Geographic Information System (ArcGIS ArcView 9.3) several maps containing water bodies, agricultural lands, construction sites, unpaved roads, aggregate mines and natural heritage features were overlayed to develop the wind erosion suseptibility map for the Lake Simcoe Airshed. *Keywords: Pollution sources, Wind erosion, Phosphorus, Deposition.*

TAO, W.[1], DEMARCHI, C.[1], JOHENGEN, T.H.[2], and HE, C.[3], [1]Department of Geological Sciences, Case Western Reserve University, Cleveland, OH, 44106-7216; [2]Cooperative Institute for Limnology & Ecosystems Research, University of Michigan, Ann Arbor, MI, 48109-1041; [3]Department of Geography, Western Michigan University, Kalamazoo, MI, 49008-5424. **Estimation of Saginaw River Nutrient and Sediment Loads.**

Saginaw River is the largest tributary of Saginaw Bay, Lake Huron. Over the years, high nutrient and sediment loads have led to the eutrophication of the bay. To tackle this problem, a target Total Phosphorus (TP) load of 440 metric tons/yr was established for Saginaw Bay, successfully diminishing eutrophication. However, algal blooms and nuisance algal beach deposits have recently returned to Saginaw Bay. Here we analyze a regression model developed to evaluate current loads using the few water quality measurements and daily discharge data available at a few points in the basin, determine the contributions of sub-watersheds to the total load, and quantify the impact of model and input uncertainty on the load figure reliability. The model takes into account the effect of discharge, rising and receding flood phases, previous storm's flushing, seasonality, and long term trends in pollution generation on Total Suspended Solids, TP, and Total Nitrogen concentrations. Results indicate that the model is able to track these dynamics well: correlation in daily concentration at the river outlet for 1998-2008 is 0.88, 0.84, and 0.75 respectively, while correlation in daily loads is above 0.95. Computation of Saginaw River's annual TP loads indicates that the target TP load of 440 metric tons has been met only during dry years. *Keywords: Saginaw Bay, Sediment load, Nutrient load.*

THEYSMEYER, T., 680 Plains Rd West, Burlington, On, L8N 3H8. **Restoring urban wetlands in Cootes Paradise, Hamilton, Ontario.**

Recovery of the 300 hectares of rivermouth marsh wetlands protected within the Royal Botanical Gardens Nature Sanctuaries are a key delisting element of the HHRAP. These Lake Ontario wetlands historically lost virtually all of the native wetland vegetation and associated flora and fauna. While introduced carp (Cyprinus carpio) were responsible for much of the wetland demise, reaching a density of approximately 800kg/ha and representing 90% of the fish biomass, several key hydraulical and water quality changes have demonstrated to be behind the incredible historical success of this species. Recovering these basic conditions is the key to

ultimate sustainability of the wetlands. Main drivers of this biological community change have been demonstrated to include lake level regulation, and water quality impairments such as high levels of ammonia, phosphorus and suspended sediment. Suspended sediment issues are principally watershed based, while the remainder are largely sewage based. *Keywords: Exotic species, Coastal wetlands, Water quality, Biodiversity.*

THOMAS, S.P.[1], PAVLAC, M.M.[1], HOLECK, K.T.[2], RUDSTAM, L.G.[2], MILLS, E.L.[2], FARRELL, J.M.[3], and BOYER, G.L.[1], [1]State University of New York - College of Environmental Science and Forestry, 1 Forestry Drive, Syracuse, NY, 13210; [2]Cornell Biological Field Station, 900 Shackleton Point Road, Bridgeport, NY, 13030; [3]Thousand Island Biological Center - SUNY ESF, Governor's Island, Clayton, NY, 13624. **A Comparative Study of Two Data Collection Systems.**

Algal blooms in the Great Lakes have been a topic of study for the past 25 years. As the movement of these blooms is better understood, the need to develop a system that will accurately monitor them has developed. For the past several years, we have operated two different systems to study data collection. The first is a land-based system located approximately 16 miles downstream of the outlet of Lake Ontario on the St. Lawrence River. The second is a buoy, located a half-mile off of the southern shore of Oneida Lake, at Shackleton Point. Several different parameters were looked at including temperature, pH, dissolved oxygen and chlorophyll. Changes, including instrumentation and data collection, were made to the systems to optimize the collection process as well as identify the problems that arise. *Keywords: Comparison studies, Water quality, Observing systems.*

THOMASEN, S.M. and CHOW-FRASER, P., McMaster University, 1280 Main St. W., Hamilton, ON, L8S 4K1. **Effectiveness of Ecological Indices in Detecting Changes to Ecosystem Health at Cootes Paradise Marsh.**

We completed a water-quality and biotic survey of Cootes Paradise Marsh, a large urban wetland of Lake Ontario, to determine if there has been an overall improvement in wetland quality following exclusion of common carp (*Cyprinus carpio*) via construction of the Cootes Paradise Fishway in 1997. Ecological indices based on water-quality, zooplankton, macrophyte and fish communities were calculated with data collected prior to and ten-years following barrier implementation. We also determined changes in wetland quality of three other coastal wetlands in the Laurentian Great Lakes for which long-term data exist: Matchedash Bay, Long Point Marsh and Turkey Point. Our results show that there has been variable improvement in wetland quality at Cootes Paradise Marsh, but compared to the three other wetlands, it is still the most degraded in all aspects studied. These results provide an opportunity to examine the progress of restoration efforts in degraded marshes of the Laurentian Great Lakes, such as Cootes Paradise and Matchedash Bay, and highlight areas that should be considered in future restoration efforts. *Keywords: Ecosystem health, Coastal wetlands, Indicators.*

THORN, M., VAILLANT, C., KURISSERY, S., and KANAVILLIL, N., Lakehead University Orillia Campus, 1 Colborne St. W, Orillia, ON, L3V 7X5. **Species diversity and succession of microalgae in biofilms developed on glass coupons suspended in northwestern part of Lake Simcoe, Orillia, ON.**

The community dynamics of microalgae with special reference to diatoms, on natural biofilms developed on glass coupons suspended in northwestern part of Lake Simcoe were studied during summer 2009. Multiple numbers (22) of glass coupons (10x3 cm^2) were suspended at a depth of 0.6 m from water surface with the help of a coupon suspension assembly for a maximum period of 30 days. Duplicate and quadruplicate coupons were removed at fixed time intervals; 1, 3, 5, 7, 10, 15, 20, 25 and 30 days after suspension. Upon removal, they were transported to the laboratory in an immersed condition with water collected from the sampling location and were analyzed for microalgal species present, their density, and biofilm thickness under 200x magnification. Nine fixed locations on each coupon surface were observed. Altogether, 28 diatom species were recorded of which *Gomphonema* sp. and *Navicula* sp. were the dominant genera. The study showed *Diatoma* sp. and *Fragilaria* sp. as initial colonizers which were overgrown by *Gomphonema* sp. and *Navicula* sp. by 20 days. The thickness of biofilm showed maximum value of 220μm by 20th day. The density of microalgae varied from 2.8x10^4 to 1.8x10^8/cm^2 on day 1 and 25, respectively. *Keywords: Biofilm, Diatoms, Lake Simcoe.*

THUSS, E.P.[1], SWEENEY, S.J.[2], and ASPINALL, J.D.[2], [1]Wilfrid Laurier University, 75 University Avenue West, Waterloo, ON, N2L 3C5, Canada; [2]Ontario Ministry of Agriculture, Food and Rural Affairs, 3rd Floor SE, 1 Stone Road West, Guelph, ON, N1G 4Y2, Canada. **LiDAR-derived DEM's enhance the resolution of ArcGeoWEPP results for "within-field-scale" soil erosion assessment to inform mitigation action deployment.**

Agricultural lands have a history of chronic soil erosion in the tributary subwatersheds of Rondeau Bay on the Lake Erie coast. Topsoil erosion results in lost productivity and negative environmental impacts from this region's farms. This study was conducted to investigate how the deployment of soil erosion mitigation actions may be informed by the application of the ArcGeoWEPP (Water Erosion Prediction Project) model. The model was applied to Rondeau Bay subwatersheds to delineate the "within-field-scale" spatial distribution of soil erosion intensity. This paper describes the development of a LiDAR-based digital elevation model (DEM) with sub-metre vertical accuracy for this region. ArcGeoWEPP results obtained with this LiDAR-based DEM were compared with those obtained with the current "provincial" DEM. This latter DEM product has a vertical accuracy coarser than 1 metre. The delineation of "within-field-scale" soil erosion spatial distribution in these subwatersheds was found to be far superior when the LiDAR-based DEM was used to render the landscape. Detailed planning for field deployment of soil erosion mitigation actions was significantly improved by using it. *Keywords: Model testing, Rondeau Bay, Sediment transport, Digital Elevation Model (DEM), Lake Erie, ArcGeoWEPP.*

TODD, A.K., Ontario Ministry of the Environment, Environmental Monitoring and Reporting Branch, Etobicoke, ON, M9P 3V6. **Urban stream water pesticide concentrations before and after Ontario's cosmetic pesticides ban.**

Pesticide concentrations were measured in surface water samples from ten urban streams, before and after an Ontario government ban in April 2009 on the sale and use of pesticides for cosmetic purposes. Laboratory methods capable of detecting analytes at the sub-nanogram per litre level were used to test for as many as 87 pesticides and 17 degradates. Three general findings can be drawn from the monitoring results. First, at low levels of detection, a large number of pesticides can be measured in Ontario's urban streams. These mixtures are comprised mostly of pesticides used for urban lawn care, but also include trace concentrations of persistent pesticides that were previously banned or phased out and pesticides that are used primarily for agriculture. Second, concentrations of pesticides in urban stream water in Ontario rarely exceed water quality criteria for the protection of aquatic life. Third, the Ontario government ban on the sale and use of cosmetic pesticides resulted in a rapid and widespread decline in stream water concentrations of pesticides used for urban lawn care. *Keywords: Pesticides, Monitoring, Urban watersheds.*

TONINGER, R. and MCDONALD, K., 5 Shoreham Dr., Downsview, ON, M3N 1S4, Canada. **Are there Wildlife Deformities and Reproductive Problems among Colonial Waterebirds in the Toronto AOC?**

Tommy Thompson Park, also known as the Leslie Street Spit, is man-made peninsula extending 5 km in to Lake Ontario in the Toronto AOC. It is recognized as a Globally Significant Important Bird Area, and is one of the most significant colonial waterbird breeding sites on the Great Lakes. The site has supported 8 species of colonial waterbirds since the mid 1970's and currently includes the largest colonies of Double-crested Cormorant, Black-crowned Night-Heron, Ring-billed Gull, Herring Gull, Caspian Tern, Common Tern, and Great Egret in the AOC. Long term population trends at the site coupled with Great Lake Basin wide changes, provide convincing incite into reproductive success within the AOC. In 2005 the TRCA conducted a study looking at the reproductive success, occurrence deformities, and contaminant levels in eggs of five colonial waterbirds found at the site. While contaminants are still present in the eggs of colonial waterbirds at the site, they appear to not occur at levels high enough to cause reproductive impairment. Collectively this review suggests that colonial waterbird success is not limited by conaminants, but is a function of predation, habitat availability and intrecolony competition. This review represents a significant step forward in finally addressing this beneficial use impairment. *Keywords: Environmental contaminants, Colonial Waterbirds, Lake Ontario, Impared water use.*

TONTO, J.F. and CHIOTTI, Q., 625 Church St, Ste 402, Toronto, ON, M4Y 2G1. **The Weather-Water Information Gateway.**

While the most obvious indicator of climate change is the shifting of the earth's temperature, the actual effects of climate change are typically felt through changes in water.

When considering adaption to climate change in Ontario, water issues are at the forefront: drought, flooding, source water protection and water quality. In order to deal with the challenges of a changing climate, different levels of government need to develop a coordinated response. In recognition of this Natural Resources Canada created the Regional Adaption Collaboratives Program (RAC)which in cooperation with the provinces will help coordinate responses to impacts of climate change through many activities including knowledge sharing. A critical component of the RAC being put forward by the Province of Ontario is the development of a Weather and Water Information Gateway. This will allow local practitioners to access water and climate data to support decision making initiatives. The Weather and Water Information Gateway (Gateway) will foster the establishment of local demonstration projects: Local Adaptation Collaboratives (LAC). These demonstration LAC's will use weather and water data to perform local analysis to make decisions on how to adapt effectively to climate change. *Keywords: Water, Climate change, Adaptation.*

TOWEY, T.P.[1], BARABAS, N.[1], DEMOND, A.[2], and ADRIAENS, P.[2], [1]LimnoTech, 501 Avis Dr, Ann Arbor, MI, 48108; [2]Department of Civil and Environmental Engineering, EWRE, 1351 Beal Avenue, Ann Arbor, MI, 48109. **Statistical Fingerprinting of PCDDs, PCDFs, and PCBs in Soil, Dust, Fish Tissue, and Human Serum Samples from the Tittabawassee River and Floodplain.**

The University of Michigan Dioxin Exposure Study (UMDES) was undertaken to address concerns of the population of Midland and Saginaw Counties related to the historic discharges of dioxin-like compounds from the Dow Chemical Company facilities, including discharges to the Tittabawassee River, a tributary of the Saginaw River. Polytopic vector analysis (PVA), a statistical fingerprinting technique, was applied to the UMDES soil, household dust, and serum datasets to evaluate exposure sources of dioxin-like compounds and to compare exposure sources between the UMDES study populations. Additionally, PVA was applied to fish tissue samples of 13 species collected in the Tittabawassee and Saginaw Rivers. This presentation will provide a comparison of congener patterns that contribute to each of the sample matrices, compare patterns found in various fish species, and comment on factors that predict the occurrence of particular congener patterns in human serum. *Keywords: Organochlorine compounds, Environmental contaminants, Sediments.*

TRENOUTH, W.[1], KAZMI, S.[1], ASNAASHARI, A.[1], GHARABAGHI, B.[1], MCBEAN, E.[1], WALTERS, M.[2], and RUDRA, R.[1], [1]University of Guelph, School of Engineering, Guelph, ON, N1G 2W1; [2]Lake Simcoe Region Conservation Authority, Newmarket, ON, L3Y 4X1. **Monitoring of Phosphorus Load in Stormwater Runoff from Urban Development Projects in the Lake Simcoe Watershed.**

Soil erosion and sediment transport by stormwater runoff may be amplified by one to two orders-of-magnitude during construction activities (USEPA, 2009). The Lake Simcoe Protection Plan (MOE, 2009) has set high standards for stormwater management, including runoff from new developments. However, with rapid growth of the urban fringe in the Lake Simcoe Watershed concerns have been raised about the impact of urban construction sites on receiving

water courses and the Lake. This research presents the results of the stormwater monitoring program, including calculation of Phosphorus Load in Stormwater Runoff generated from construction sites under different phases. Stormwater runoff quantity and quality have been monitored in a new major housing development project in the Town of Innisfil, a single residential construction site on the Lake Simcoe shoreline and an elementary school expansion project in Cookstown. Runoff flow rate and water quality parameters, including total suspended solids (TSS) and total phosphorus (TP) were measured for a range of storm events. Turbidity of runoff samples were also measured to determine if turbidity can be used as a cost-effective surrogate water quality indicator for both TSS and TP. *Keywords: Water quality, Construction Sites, Sediment load, Stormwater Management, Phosphorus, Lake Simcoe.*

TROY, C.D.[1], AHMED, S.A.[1], and HAWLEY, N.[2], [1]Purdue University, School of Civil Engineering, 550 Stadium Mall Drive, West Lafayette, IN, 47907-2051; [2]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Rd, Ann Arbor, MI, 48108-9719.
Near-inertial internal waves in southern Lake Michigan: observations, analysis, and consequences.

In large lakes, strong thermal stratification and weak physical forcings render importance to processes that can accomplish summertime turbulent mixing. Near-inertial internal waves are ubiquitous, energetic features in many large lakes during the stratified summer season; however, analysis and observations of circulation and thermal structure in large lakes typically focuses on the "mean" (low-passed) features, neglecting near- and super-inertial processes that can have important effects on vertical mixing and horizontal exchange. Observations from an intensive summer measurement campaign in southern Lake Michigan are presented to highlight properties of near- and super-inertial internal waves as they relate to meteorological forcing, cross-isobath exchange, and potential for biological and sediment transport. This field experiment involved temperature, current, and suspended sediment measurements at 7 moorings during the 2009 stratified period, and provided detailed data with relatively high temporal and spatial resolution. Additional analysis details the magnitudes and timescales of cross-isobath excursions of the summer thermocline and the evolution of these movements through the stratified period, as well as the likelihood of breaking of observed internal waves using standard stratified shear flow metrics (Ri). *Keywords: Coastal processes, Turbulence, Hydrodynamics, Internal waves, Observing systems.*

TROY, C.D. and AHMED, S.A., Purdue University, 550 Stadium Mall Drive, West Lafayette, IN, 47907-2051.
Implications of Great Lakes internal waves for biological dispersion: analysis and observations.

Internal waves are ubiquitous wind-related features during the thermally-stratified summer period in the Great Lakes. These waves exist on a wide range of spatial and temporal scales, playing an important (if not often dominant) role in biological transport and dispersion. The role of internal waves in biological dispersion has been investigated in oceanic settings (e.g. in producing planktonic thin layers), but remains relatively unexplored in the Great Lakes. This is especially true for higher frequency, near- and super-inertial internal waves. In this talk, we

examine the potential passive biological transport and dispersion implications of these waves, using idealized arguments augmented with observations from an intensive field experiment in southern Lake Michigan during the 2009 stratified period. *Keywords: Dispersion, Hydrodynamics, Internal waves, Coastal ecosystems, Lake Michigan.*

TRUMPICKAS, J.J.[1], SHUTER, B.J.[2], and MINNS, C.K.[3], [1]Dept. of Biology and Redpath Museum, McGill University, 859 Sherbrooke St. W., Montreal, QC, H3A2K6; [2]Aquatic Research and Development Section, Ontario Ministry of Natural Resources, 300 Water St., Peterborough, ON, K9J8M5; [3]Dept. of Ecology and Evolutionary Biology, University of Toronto, 25 Harbord St., Toronto, ON, M5S 3G5. **Characterizing Patterns of Nearshore and Whole-Lake Water Temperatures in the Great Lakes.**

Nearshore waters are among the most biological productive and anthropogenically developed in the Great Lakes. Water temperatures at nearshore sites affect both biological processes and human uses. Empirically linking nearshore and whole-lake temperatures assists in understanding and predicting the impacts of stressors such as climate change on Great Lakes water temperatures. Daily water temperatures from 34 nearshore sites in Lakes Superior, Michigan, Huron, Erie, and Ontario were compared with whole-lake average surface water temperatures predicted by a previously developed model linking water temperatures to regional air temperatures. Nearshore datasets ranged in length from 4 to 58 years. Nearshore – whole lake water temperature differences could be grouped into a small number of distinctly different seasonal patterns, which were characterized using quantile regression. Statistical associations linking these patterns to the physical characteristics of each site were explored. *Keywords: Coastal processes, Climatic data, Climate change.*

TRYON, B., MCDONALD, K., and TONINGER, R., 5 Shoreham Drive, Downsview, On, M3N1S4. **Bird Conservation in the Living City: A Balance of Fundamental Research and Education at Tommy Thompson Park Bird Research Station.**

Toronto and Region Conservation launched the Tommy Thompson Park Bird Research Station (TTPBRS) in 2003 to improve the awareness and protection of birds in Toronto. The research station is located within Canada's largest city, a site of global significance to bird populations. Tommy Thompson Park is a 5 km long man-made peninsula connecting an extensive network of urban park spaces that form a corridor of greenspace connecting Lake Ontario with the Oak Ridges Moraine. The station is one of 25 Canadian Migration Monitoring Network stations in Canada and to date has banded over 30,000 birds representing more than 240 species. Collected data indicate that the site is an important stopover area for migratory birds, comparable to known sites such as Long Point and Point Pelee. This data is used to support local land management decisions and regional planning initiatives, as well as to assess continental population trends. The location of the research station in Toronto offers an outstanding opportunity to engage the public in environmental education. Through programs such as Winged Migration, a curriculum based education program, TTPBRS interacts with thousands of visitors on an annual basis. The station represents a unique opportunity to balance fundamental research and public education. *Keywords: Environmental education, Monitoring, Avian ecology.*

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TRYON, K.L.[1], BOWEN, G.S.[2], and BROWN, S.[3], [1]65 Harwood Ave S, Ajax, on, L1S 2H9; [2]5 Shoreham Dr, Downsview, on, M3N 1S4; [3]300 - 675 Cochrane Dr W Tower, Markham, on, L3R 0B8.
Ajax Stormwater Quality Master Plan Environmental Assessment for Sewersheds that Discharge Directly to Coastal Marshes and Lake Ontario.

Beach posting and algal fouling along the Ajax waterfront are currently limiting public use and enjoyment. Recognizing that local stormwater contributions maybe a contributing factor to degradation of water quality, the Town of Ajax is in the process of developing a stormwater master plan to improve runoff for urban drainage areas that discharge directly to coastal marshes, creeks and Lake Ontario. Development in the Town was initially centered on the Defense Industries Ltd. (DIL) plants which were located south of Highway 401 during the Second World War Land use in southern Ajax is an even split between commercial/industrial and low-density residential. This area is entirely built-out and with a few exceptions, any future development will be infill development or redevelopment. The master plan is a focused look at what improvements can be achieved to reduce influences of stormwater on nearshore areas of Lake Ontario. This plan will identify management strategies and water quality improvements for each sewersheds. Through technical reviews and stakeholder consultation, a recommended approached will be developed identifying costs, priority sewersheds and stormwater practices to be imp *Keywords: Environmental policy, Water quality, Watersheds.*

TSIPLOVA, K.[1], JIAO, Y.[2], REID, K.B.[3], and NUDDS, T.[1], [1]Department of Integrative Biology, University of Guelph, Guelph, ON; [2]Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA; [3]Ontario Commercial Fisheries Association, 45 James Street, Blenheim, ON, N0P 1A0.
Bioeconomic Evaluation of Harvest Control Rules for Lake Erie Walleye Fishery.

This study presents a multi-disciplinary approach to evaluating harvest policies. Using the Lake Erie walleye (Sander vitreus) commercial fishery as a case study, we developed a bioeconomic simulation framework to examine the effects of alternative harvest control rules on both biological and economic performance indicators in the presence of uncertainty about the stock size. The simulation framework contains constant fishing mortality and abundance-based harvest control rules, including the ones currently used to set Lake Erie walleye harvest, and which range from conservative to liberal exploitation rates. The biological model describes stochastic age-structured population dynamics of walleye population and the economic model generates short-run gross and net revenues for the walleye commercial harvesting operations. We ranked harvest control rules in terms of expected abundance, catch, landings and value of landings, and present value of net revenues, as well as in terms of probability of either economic or biological indicators falling below some undesirable threshold. Our results emphasize the need for examining the trade-offs between biological and economic objectives, as well as the trade-offs between the expected magnitude of and variation in catch and profits. *Keywords: Risk assessment, Bioeconomic, Fisheries.*

TU, C.[1], PISAPIO, J.[2], and LAWRIE, D.[1], [1]Toronto and Region Convervation Authority, 5 Shoreham Drive, Downsview, ON, M3N 1S4; [2]Ministry of Natural Resources, Aurora District, 50 Bloomington Road, Aurora, ON, L4G 0L8. **Measuring the Success of Watershed Based Fisheries Management Plans: Science and Society Meet.**

The Toronto and Region Conservation Authority (TRCA), in partnership with the Ontario Ministry of Natural Resources (OMNR), is in the process of finalizing two watershed-based Fisheries Management Plans (FMPs) for the TRCA jurisdiction: Rouge River and Don River. Although setting management priorities is not unique to these FMPs, defining a framework to quantify and measure the successful implementation of an FMP has not been done before. Criteria, on which to evaluate management success, has been developed and tied to recommended implementation projects that: address the driving factor(s) limiting target fish species production, attain measurable ecological gains, close knowledge gaps and consider the feasibility to complete work within specified timelines. Also, these FMPs strive for more specific recognition towards advancement into the realm of early land use planning. There is discussion as to whether only interim success can be evaluated prior to landscape stabilization, which will not happen until urbanization is complete within a watershed, and then sufficient time elapsed for streams to respond. This will take decades during which the links between upland changes and aquatic system condition must be understood and protected in order to achieve the FMPs goals of aquatic health and biodiversity. *Keywords: Fish management, Rouge River, Urban watersheds, Evaluting Success of Fish Management Plans, Ontario Ministry of Natural Resources.*

TUTTY, L.A., University of Toronto Geology. Earth Sciences Building. 22 Russell St, Toronto, ON, M5S3B1. **Using Multibeam Sonar Acoustic Technology to Create Benthic Ecology Habitat Maps in Lake Huron, Fathom Five National Marine Park.**

With increasing population and climate pressures affecting the Laurentian Great Lakes it has become increasingly important to determine the health of the ecosystem as well as the most effective methods of protection. Benthic invertebrates are at the base of the food chain and form a large percentage of the diet for native fish species including Lake Whitefish and, indirectly, sport fish such as Lake Trout. During the last decade there has been a precipitous drop in one keystone species of shrimp-like amphipod, Diporeia. The ecosystem effects of further changes are unknown and there is a need to develop methodologies for rapid assessment for benthic communities over large geographic areas. Pioneering work in marine areas has found some success with acoustic technology such as multibeam sonar, but little has been done inland. The current study is built on a multibeam sonar framework and includes approximately 70 physical sample sites over a 10.5km^2 area; each site has benthic invertebrate, lakebed sediment and water samples in addition to underwater video recordings. *Keywords: Acoustics, Benthos, Bottom sampling.*

TWISS, M.R., Great Rivers Center at Clarkson University, Potsdam, NY, 13699. **Effects of Dissolved Organic Carbon on FluoroProbe-Based Assessment of Great Lakes Phytoplankton.**

The influence of chromogenic material (yellow substances [YS], colored dissolved organic matter [CDOM]) in Great Lakes water on the operation of a submersible pigment-based fluorimeter (FluoroProbe; bbe Moldaenke, GmbH) was assessed. Study focused on pelagic regions of Lake Ontario and Lake Huron in Spring and Summer and employed up to three FluoroProbes for simultaneous comparisons of performance. Conclusions from this study are: FluoroProbes are not equally accurate; YS correction factors obtained by FluoroProbes are instrument specific; there is a seasonal difference in YS correction factors between summer and spring; there is a difference in YS correction factors among strata in a lake for Lake Ontario but not for Lake Huron. The differences among YS correction factors observed is attributed to chromogenic material that was assessed independently by measuring CDOM using a separate fluorimetric technique and by measurement of in situ UV absorption coefficients. Accuracy of the FluoroProbe regarding pigment-based phytoplankton community characterizations must await completion of microscopic analyses that was not included in this study. This research was funded by USEPA-GLNPO Project GL2007-60. *Keywords: Monitoring, Data acquisition, Phytoplankton.*

ULLRICH, D.A., Great Lakes and St. Lawrence Cities Initiative, Chicago. **Renovating Great Lakes Governance for sustainability: Cities as a Catalyst.**

The role of cities and other local governments in advancing Great Lakes and St. Lawrence sustainability has expanded significantly over the past ten years. The cities have always been on the front lines delivering drinking water, wastewater management, water recreation, land use management, and many other services that have major implications for the resource. However, in the past, federal, state, and provincial authorities have not included cities to any significant degree in policy formulation and strategy development and implementation. This is changing rapidly. Cities are uniquely situated geographically and by the nature of their order of government to serve as a catalyst for action and results for the benefit of the resource. Because of their proximity to the resource and because such a large majority of the people in the federal, state and local jurisdictions on the Great Lakes and St. Lawrence live in the cities, there is a greater sense of urgency in dealing with the issues at hand. Local elected officials see the problems and hear about them from their constituents on a daily basis. Cities are also in a better position to put plans into tangible action on the land and in the water on an expedited basis. Because of all of this, local government must be an equal partner in a renovated governance structure. *Keywords: Decision making, Legislation.*

UZARSKI, D.G.[1], COOPER, M.J.[2], and MURRY, B.A.[1], [1]Department of Biology and CMU Biological Station, Central Michigan University, Mount Pleasant, MI, 48859; [2]Department of Biological Sciences, University of Notre Dame, Notre Dame, IN, 46556. **Water Levels Impacting Great Lakes Coastal Wetlands: Invertebrate Community Composition Responses.**

After loosing greater than 50% of our Great Lakes coastal wetlands to development and agriculture, we are just realizing the importance of these systems to the overall health of the

Great Lakes. Coastal wetlands serve many critical physical, chemical, and biological functions. Great Lakes water level fluctuations impact coastal wetland structure and function. Therefore, alterations in hydrology, either natural or anthropogenic, shape communities and make community composition dynamic. We sampled invertebrate communities from wetlands of Lakes Huron and Michigan from 1998-2009. Water levels fluctuated drastically during that time. However, our sampling protocols attempted to isolate hydrologic variables. We sampled invertebrate communities within plant zones that migrated towards open water or shoreward depending on the direction of the water level change and depth was kept relatively constant. We used non-metric multidimensional scaling and Pearson correlation to relate invertebrate community composition to hydrology. With habitat, water quality, and depth held relatively constant, Great Lakes water levels still impacted invertebrate communities. Therefore, our results suggest that alterations of the natural hydrologic regimes have the potential to impact these ecosystems in ways that have not yet been considered. *Keywords: Benthos, Wetlands, Water level.*

VAN ARKEL, G.[1] and SNODGRASS, W.J.[2], [1]Golder Associates Limited, 2390 Argentia Road, Mississauga, ON, L5N 5Z7; [2]City of Toronto, Metro Hall, 55 John Street, 18th Floor, Toronto, ON, M5V 3V6. **Forecast of trends in Nutrient Content and oxygen Regimes in Toronto Harbour over the past Century.**

This paper uses a nutrient dissolved oxygen model to estimate the trend in algal and dissolved oxygen beneficial uses for the Toronto Area AOC, as a scientific support to understanding the related 'beneficial use impairments' for the Toronto AOC. The time focus for the evaluation is the past century by accounting for estimates of changes in nutrient and BOD loadings from the major watershed flowing into the Inner Harbour, the Don River watershed. As a context piece, the paper also presents estimates of changes in nutrient loadings over the past century in two other water bodies (Hamilton Harbour, Lake Simcoe) to contrast the differences in oxygen regimes between the three water bodies. The evaluation is also tied to measures changes in benthic invertebrate observed in Toronto Harbour, using Sediment Oxygen Demand as the surrogate. *Keywords: Nutrients, Oxygen, Sediments.*

VAN BOCHOVE, E.[1], DENAULT, J.T.[1], LECLERC, M.L.[1], THÉRIAULT, G.[1], DECHMI, F.[2], ALLAIRE, S.E.[3], ROUSSEAU, A.N.[4], and DRURY, C.[5], [1]Soils and Crops Research and Development Centre, Agriculture and Agri-Food Canada, Québec, QC, G1V 2J3, Canada; [2]Centro de Investigación y Tecnología Agroalimentaria, Gobierno de Aragón (CITA-DGA), Unidad de Suelos y Riegos, Zaragoza, 50.07999999999999829, Spain; [3]Horticultural Research Center, Université Laval, Québec, QC, G1K 7P4, Canada; [4]Institut national de la recherche scientifique, Centre Eau, Terre et Environnement, Québec, QC, G1K 9A9, Canada; [5]Greenhouse and Processing Crops Research Centre, Agriculture and Agri-Food Canada, Harrow, ON, N0R 1G0, Canada. **Changes in agricultural management decreased the risk of water contamination by phosphorus in the Great Lakes Watersheds.**

This study presents an in-depth analysis of risk of water contamination by phosphorus from agriculture in the major Great Lakes watersheds of Canada. The relative level of risk and

25-year trend (1981-2006) of water P contamination in agricultural watersheds of the Great Lakes basin have been estimated using the indicator of risk of water contamination by phosphorus (IROWC-P) developed for Canada. The Canadian watersheds of the Great Lakes basin showed a 39% reduction in their P applications in excess of crop requirements between 1981 and 2006, mostly due to the better management of fertilizer-P, bringing the Ontario provincial P-balance close to equilibrium in 2006. Vulnerable areas with high soil P saturation values were found south of Kitchener in the Lower Grand River watershed and east of Lake Simcoe. IROWC-P values, driven by the synergy of high soil P saturation, deep drainage amounts and connectivity to the tile drains, were significantly ($p<0.001$) but weakly correlated ($r= 0.57$) with TP monitoring data. Overall, the risk of water contamination by P remains acceptable (very low to moderate) in most Great Lakes watersheds but more attention is required in some areas to better manage P application (fertilization and manure addition) and mitigate P transfer to the waterbodies. *Keywords: Phosphorus, Watersheds, Risk assessment.*

VAN GEEST, J.L.[1], POIRIER, D.G.[2], SOLOMON, K.R.[1], and SIBEY, P.K.[1], [1]University of Guelph, Guelph, ON; [2]Ontario Ministry of the Environment, Toronto, ON.
The effectiveness of laboratory bioaccumulation methods in reflecting environmental exposures and bioavailability.

The most direct and ecologically relevant approach to assess bioaccumulation is to measure contaminants in organisms collected or exposed in the field. However, the use of mobile and long-lived organisms such as fish may prove difficult to delineate zones of contamination and sampling of benthic organisms is limited due to the workload constraints of obtaining sufficient biomass. Laboratory bioaccumulation methods cannot completely replace field measurements, but attenuate some of the associated issues (cost, timing, variability) and offer more flexibility. Work was recently completed on the development and standardization of an Ontario Ministry of the Environment laboratory protocol for measuring bioaccumulation from field-contaminated sediments in the fathead minnow Pimephales promelas, the oligochaete Lumbriculus variegatus, and the mayfly nymph Hexagenia spp. In this presentation, we compare laboratory-derived tissue residues and biota-sediment accumulation factors with available field data from nine corresponding contaminated sites (some located in the Great Lakes and its tributaries). We discuss the extent to which the laboratory methods reflect environmental exposure, and how they may be used to corroborate field investigations, rank/prioritize the clean-up of sites, and assess the effectiveness of remediation. *Keywords: Environmental contaminants, Sediments, Bioaccumulation.*

VAN VLIET, D.J.[1], BELLAMY, S.R.[1], GABRIEL, C.[1], NEVILLE, C.J.[2], JONES, J.P.[3], DELANEY, P.[4], YING, Q.[4], GARRAWAY, M.[5], and MILFORD, L.[5], [1]AquaResource Inc., Waterloo; [2]S.S. Papadopulos and Associates, Waterloo; [3]Univerisity of Waterloo / Alberta Research Council, Waterloo; [4]DHI Water and Environment, Cambridge; [5]Ministry of Natural Resources, Peterborough.
Conjunctive Models and the Assessment of Cumulative Hydrologic Impacts.

The Province of Ontario is completing an assessment of conjunctive hydrologic models and their ability to better predict cumulative hydrologic impacts. Conjunctive models are developed to simulate coupled groundwater/surface-water flow in one or more watersheds by simultaneously simulating flow across the land surface, within subsurface saturated and unsaturated materials, and within streams and lakes. This assessment includes three models including Mike SHE, GSFLOW and Hydrogeosphere and evaluates each model with respect to its ability to meet the Province's objectives including cumulative hydrologic impacts considering water takings, land use change and climate change. This presentation presents the results of this study and a case study which demonstrates the application of the models and the interpretation of results to evaluate cumulative hydrologic impacts. *Keywords: Hydrologic budget, Integrated modelling, Model studies, Conjunctive modelling, Watersheds, Cumulative impacts.*

VELIZ, M.A., Rural Route # 3, 77108 Morrison Line, Exeter, ON, N0M 2G0. **Watershed Planning: Linking Individuals to the Great Lakes.**

Rural non-point source water pollution comes from many sources that vary both temporally and spatially from dispersed sources such as individual homes, farms, or construction sites. Improvements to water quality may therefore be best identified and acted upon by individual property owners. Linking individual actions to downstream water quality condition can be achieved through watershed planning. The North of Bayfield, Ontario area consists of 20 small streams that flow directly to Lake Huron. During the development of a North Bayfield Watershed Plan there have been workshops and watershed tours to explain the importance of rural best management practices that hold water, and reduce sediment and nutrients at seemingly insignificant sources. Over 30 projects have been completed or initiated in this 40-km^2 area since the planning process began in 2007. Watershed planning combined with an emphasis on individualized environmental action plans will help to enhance and protect Lake Huron. *Keywords: Lake Huron, Public participation, Watersheds.*

VERHAMME, E.M. and DEPINTO, J.V., LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108. **An Analysis of Past, Present, and Future Concentrations of PCBs in Lake Ontario; Are we there yet?**

The documented decline of PCB concentrations in lake trout fish tissue and the water column of Lake Ontario suggest that PCB loads are declining exponentially throughout the Lake Ontario Basin. While this may be true for some sources, recent mass balance modeling work by the authors illustrate that PCB loads from external sources (tributaries and the atmosphere) are only part of the story. The release of PCBs from bottom sediments (a legacy of historical loads that have accumulated in sediments) will continue to impact water column concentrations despite our best efforts to reduce external loads well into the middle of this century. Current data estimate the sediment feedback at 25% of the total PCB load to Lake Ontario (excluding atmospheric exchange). By 2050 that number will rise to over 75% if current load reductions continue. A recent effort by the State of New York and the USEPA aims to develop a TMDL for Lake Ontario that will meet the state's water quality standard of 1 pg/L for total PCBs. We will present a roadmap with several alternatives that allow the state to develop a TMDL for a legacy

contaminant and also show how close we are to meeting other PCB guidelines established by others. *Keywords: Model studies, Lake Ontario, PCBs.*

VERMEER, A., YANG, R., <u>WATSON, S.B.</u>, EDGE, T., and GUO, J., Environment Canada, CCIW, 867 Lakeshore Rd, Burlington, ON, L7R 4A6. **Caffeine and optical brighteners as wastewater markers: spatial and temporal patterns in Lake Ontario rivers, inshore and open waters and drinking water intakes.**

Caffeine and fluorescent whitening agents (FWAs) have been used to detect domestic wastewater plumes in surface waters. We investigated the seasonal and spatial variance of these biochemical tracers and other indicators across Lake Ontario at drinking water plant intakes, coastal areas and offshore sites as part of a major source water protection initiative between 2007- 2009. Samples were also collected in a sewage treatment plant (STP) at different stages of treatment.. Preliminary results showed high seasonal variability in caffeine and FWAs, with intermittent peaks often following severe storm events. Highest levels were found in the major rivers, rather than proximal to STPs. Overall, caffeine levels at most coastal sites were consistently low (<10- 35ng/L) although sites near STP outfalls showed occasional peaks reaching 165ng/L. Concentrations in the Credit and Humber Rivers were generally higher (mean 76 and 217 ng/L resp) with a maximum of 836ng/L in the Humber, which receives intermittent overflow from combined storm sewers. By comparison, average concentrations of caffeine and FWA in the raw STP influent were consistently high (<20000ng/L) but greatly reduced by the primary treatment process (~98%), with a further ~24% by chlorination, and final effluent concentrations (~10ng/L), comparable to inshore sites *Keywords: Drinking water, Wastewater, Fecal tracers, Caffeine.*

<u>VILLARD, P.V.</u>[1], DOUCETTE, J.[1], THOMAS, J.S.[2], and MORRIS, R.[2], [1]Geomorphic Solutions, 141 Brunel Road, Mississauga, ON, L4Z 1X3; [2]Credit Valley Conservation,1255 Old Derry Road, Mississauga, ON, L5N 6R4. **Recent Evolution of Rattray Marsh, Mississauga, Lake Ontario.**

Rattray Marsh is unique barrier wetland along Lake Ontario. It has been heavily impacted by the urbanization of its contributing watershed, Sheridan Creek. Credit Valley Conservation has been examining potential restoration options for the barrier marsh. An understanding of systematic adjustments within the marsh as the watershed urbanized allows for informed assessment restoration alternatives. Interpretation of historical aerial photographs, as well as a series of sediment cores, provides insight into systematic adjustments, rates of change, and potential future form of the barrier marsh. The evolution of the marsh is examined in context of the urban development pressures and potential restoration options. *Keywords: Sediment load, Deposition, Coastal wetlands.*

<u>WALL, G.J.</u>, KING, D.J., and PLAWIUK, A.N., The Soil Resource Group, 50 Crimea St., Guelph, ON, N1H 2Y6. **Agricultural land management and water quality data evaluation in representative agricultural watersheds in the Grand River and Thames River basins.**

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Agricultural watershed contribution to the nutrient loading of the Great Lakes was monitored during the 1970's and found to be significant. Since that time, considerable changes have occurred in agricultural land use and management practices, and the availability of public funds for education and remedial practices for nonpoint source pollution control. This study was initiated to monitor agricultural land use changes and associated water quality in representative agricultural watersheds in southern Ontario. Two small agricultural watersheds that were monitored in the earlier studies were instrumented and monitored over a 2 year period for discharge, as well as sediment, nutrient, and pathogen concentrations. Changes in agricultural land use, management practices, and water quality concentrations and loadings were compared relative to data collected in the 1970's. Among other land use changes since the 1970's, both watersheds showed an increase in Animal Units and percentage of land used for row crops, two factors which the earlier studies identified as having an impact on water quality. Preliminary results also indicate that concentrations of nutrients and sediment have risen since the 1970's. *Keywords: Great Lakes basin, Agricultural land management, Water quality, Watersheds.*

WALLACE, A.M. and JARVIE, S.W., Toronto and Region Conservation Authority, 5 Shoreham Drive, Downsview, ON, M3N 1S4. **Long-term Water Quality Monitoring in the Toronto and Region AOC.**

The Toronto and Region Area of Concern (AOC) was first recognized by the International Joint Commission in 1985 due to several issues associated with historic industrialization and continuing urbanization including poor water quality. The Toronto and Region Conservation Authority (TRCA) initiated a Regional Watershed Monitoring Program (RWMP) in 2001 to monitor watershed health and support the reporting requirements of TRCA, the Toronto Remedial Action Plan, and individual watershed/waterfront councils and alliances while furthering the interests of municipal, provincial and federal partners. Through the RWMP, stream water quality is monitored at 29 sites in the Toronto and Region AOC, and builds on historical data from several partners. The Toronto AOC area is large, the tributaries are varied and the types and levels of pollutants vary both spatially and temporally. This presentation will discuss current ambient water quality conditions for several nutrients and metals along with chloride and E. coli in the tributaries of the Toronto and Region AOC (Etobicoke Creek, Mimico Creek, Humber River, Don River, Highland Creek, Rouge River). Temporal trends at several key sites will also be presented. In addition, challenges and recommendations for assessing water quality in the Toronto AOC will also be discussed. *Keywords: Monitoring, Water quality, Watersheds.*

WALSH, M.G.[1], LANTRY, B.F.[1], RUDSTAM, L.G.[2], and BOSCARINO, B.T.[2], [1]USGS Lake Ontario Biological Station, 17 Lake Street, Oswego, NY, 13126; [2]Cornell Biological Field Station, 900 Shackelton Point Road, Bridgeport, NY, 13030. **Population characteristics and distribution patterns of Hemimysis anomala.**

The invasive littoral mysid, Hemimysis anomala, was discovered in southeastern Lake Ontario in 2006. Initial research on the species focused on developing standardized sampling

methods and evaluating lake-wide spatial distribution based on presence and absence data from shoreline sampling, but has recently expanded to include better evaluating the potential role of Hemimysis in the nearshore foodweb. During summer 2009 we completed the first of a two year field study on Hemimysis ecology in southeastern Lake Ontario; we sampled nearshore waters ranging 3-24 m monthly from June-November to evaluate seasonal and depth distribution of Hemimysis, life history characteristics of the Hemimysis population including size structure and fecundity, and availability of zooplankton prey. We will further evaluate the nearshore foodweb using stable isotope analyses on several trophic groups, including vegetation, Hemimysis, native zooplankton, introduced zooplankton (Bythotrephes longimanus), and planktivorous fish (alewife, Alosa pseudoharengus). We will discuss our preliminary results within the context of possible impacts of Hemimysis on nearshore foodwebs in the Great Lakes. *Keywords: Lake Ontario, Mysid, Invasive species, Zooplankton.*

WALTERS, M.J.[1], WOOD, D.G.[1], BALDWIN, R.J.[1], GOODYEAR, D.R.[1], EL-FARHAN, R.M.[2], BENELMOUFFOK, D.J.[2], WINTER, J.G.[3], STAINSBY, E.A.[3], LONGSTAFF, B.R.[1], and ANTOSZEK, J.M.[3], [1]Lake Simcoe Region Conservation Authority, 120 Bayview Parkway, Newmarket, ON, L3Y 4X1; [2]Louis Berger Group Inc., 2300 N Street, NW, Washington, DC, 20037; [3]Ministry of the Environment, 125 Resources Road, Etobicoke, ON, M9P 3V6. **State of the Lake Simcoe Watershed.**

Substantial progress has been made to increase our scientific understanding of the Lake Simcoe ecosystem form and function. This knowledge has been used to develop integrated watershed management strategies incorporating recommendations for policy and remedial best management practices to achieve resource targets. Implementation of the management strategy over the past two decades has demonstrated to have significantly reduced some of the ecosystem impacts associated with human land use activities. This presentation will review the past and current watershed management activities and demonstrate the benefits of an adaptable watershed management planning approach. It will also identify emerging ecological issues and threats, along with further actions and innovative solutions that will be necessary to continue to achieve resource targets. *Keywords: Lake Simcoe, Ecosystem health, Remediation.*

WANG, B.[1], LIAO, Q.[1], and BOOTSMA, H.A.[2], [1]Department of Civil Engineering and Mechanics, University of Wisconsin-Milwaukee, Milwaukee, WI, 53211; [2]Great Lakes WATER Institute, University of Wisconsin-Milwaukee, Milwaukee, WI, 53204. **The development of the second generation of in situ Particle Image Velocimetry (PIV).**

A self-contained UnderWater Miniature Particle Image Velocimetry (UWMPIV) system is developed. It has been successfully deployed in several lakes and rivers to study turbulent flow structures of the bottom boundary layer. The first generation of UWMPIV has several shortcomings that limit its potential capabilities. We have designed an improved system, which consists of two lasers and two cameras. With the new design, the second generation of UWMPIV can measure flows with much higher current speeds and turbulence intensities. Also the temporal resolution and measurement accuracy have been significantly improved. We will present

examples to demonstrate how the system can be applied to estimate the bottom shear stress under unsteady flow conditions. *Keywords: Hydrodynamics, Cameras, Sediment resuspension.*

WANG, J., BAI, X., LESHKEVICH, G., COLTON, M., CLITES, A., and LOFGREN, B., NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Road, Ann Arbor, MI, 48108. **Severe Great Lakes Ice Cover in Winter 2008/09: Contribution of AO and ENSO.**

After nearly a decade of little ice cover, the Great Lakes experienced extensive ice cover during the 2008/09 winter, similar to the amount of ice formation during the 2002/03 winter. The bi-weekly ice area during the 2008/09 winter reached 75,010 km in Lake Superior on March 2, 2009, nearly twice the maximum climatology (~40,000 km). The maximum ice area for all five Great Lakes during the 2008/09 winter was 166,380 km , which is comparable to the amount during the last severe winter of 2002/03 (166,423 km) although smaller than the previous severe winters of 1976/77 (201,655 km), 1978/79 (197,853 km), 1993/94 (189,940 km), and 1995/96 (184,505 km). The causal mechanism of the severe ice cover was the combined effects of an unusual positive Arctic Oscillation (AO) and a La Nina phase of El Nino and Southern Oscillation (ENSO) in the Pacific, leading to a negative surface air temperature (SAT) anomaly of ~ -2 to -4 C over the Great Lakes. At the same time, the strong positive AO pattern also caused a warming in the Barents Sea (~ +10 C) and the Arctic Ocean (~ +6 C). *Keywords: Climate change, Arctic Oscillation, Ice, ENSO, Great Lakes basin, Teleconnection.*

WANG, J.[1], HU, H.[2], SCHWAB, D.[1], LESHKEVICH, G.[1], BELETSKY, D.[2], HAWLEY, N.[1], and CLITES, A.[1], [1]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Road, Ann Arbor, MI, 48108; [2]University of Michigan, CILER, 4840 S. State Road, Ann Arbor, MI, 48108. **Development of the Great Lakes Ice-circulation Model (GLIM): Model-data fusion and sensitivity studies.**

To simulate ice and water circulation in Lake Erie over a yearly cycle, a Great Lakes Ice-circulation Model (GLIM) was developed by applying a Coupled Ice-Ocean Model (CIOM) with a 2-km resolution grid. The hourly surface wind stress and thermodynamic forcings for input into the GLIM are derived from meteorological measurements interpolated onto the 2-km model grids. The seasonal cycles for ice concentration, thickness, velocity, and other variables are well reproduced in the 2003/04 ice season. Satellite measurements of ice cover were used to validate GLIM with a mean bias deviation (MBD) of 7.4%. The seasonal cycle for lake surface temperature is well reproduced in comparison to the satellite measurements with a MBD of 1.5%. Additional sensitivity experiments further confirm the important impacts of ice cover on lake water temperature and water level variations. Furthermore, a period including an extreme cooling (due to a cold air outbreak) and an extreme warming event in February 2004 was examined to test GLIM's response to rapidly-changing synoptic forcing. *Keywords: Model studies, Ice concentration, Climatology, Coupled ice-ocean model, Ice, Lake Erie.*

WATKINS, J.M., MILLS, E.L., RUDSTAM, L.G., and SEIDEL, D.P., Cornell Biological Field Station, 900 Shackleton Point Rd, Bridgeport, NY, 13030. **Coexistence of the native amphipod *Diporeia* and *Dreissena bugensis* in the New York Finger Lakes.**

Despite extensive population declines in the lower Great Lakes, the native amphipod *Diporeia* has persisted in many smaller lakes of North America including the New York Finger Lakes. This persistence is particularly interesting in Cayuga and Seneca Lakes where the amphipod coexists with abundant quagga mussels. Terrestrial matter in the sediments is thought to provide a food source that is not intercepted by mussel competitors. We investigated the Cayuga Lake anomaly in a series of experiments. Exposure experiments over a 28 day time period demonstrated that there is no significant difference in the survival of *Diporeia* (overall avg 92%) in no mussel controls and exposure levels as high as 10000 mussels per m^2. The addition of terrestrial organic matter did not improve survival rates. Substrate preference experiments demonstrated a clear selection of substrates with live quagga mussels over mussel free substrates. Feeding trials compared diets in natural mud, phytoplankton, terrestrial organic matter, and quagga mussels with and without periphyton. Highest survival was for *Diporeia* in the treatments with a natural mud substrate and the trial with no substrate but accompanying quagga mussels with periphyton. Fatty acid measurements assess nutritional effects of these food settings. *Keywords: Benthos, Dreissena, Diporeia.*

WATSON, S.B.[1], KLASS, T.[2], PAYTAN, A.[2], KENDALL, C.[3], SILVA, S.[3], and OSTROM, N.[4], [1]Environment Canada, CCIW 867 Lakeshore Rd, Burlington, ON, L7R 4A6; [2]Institute of Marine Sciences UCLA, 1156 High St, Santa Cruz, CA, 95064; [3]United States Geological Survey, Menlo Park, CA, USA; [4]Michigan State University, Dept of Zoology, East Lansing, MI, 48824, USA. **The use of stable isotopes to measure phosphate release from anoxic sediments in Lake Erie.**

Despite earlier remediation, a recent resurgence in Lake Erie phosphorus (P) levels has been observed. It is thus critical to re-evaluate previous nutrient models based on a predominance of external point-source loading. Annual summer hypolimetic anoxia is well documented in the deep Central basin, but the associated sediment P diagenesis and release usually inferred from mass calculations and its relative importance has not been recently assessed. To address this, we compared the δ18Op isotopic composition of surficial sediment phosphate (PO4) from deep anoxic and oxic areas to δ18Op values in water overlying the sediments, in upper oxygenated layers, major tributaries and wastewater treatment plants. Our preliminary data suggest that this technique provides a valuable tool to assess internal loading, which represents a significant PO4 source in the lake. Water from the West and Central basins had δ18Op values ranging from +10‰ to +17‰. During stratification, anoxic hypolimnetic δ18Op values in the Central basin (~17‰) were typically higher than epilimnetic signatures (<14‰). In comparison, weakly adsorbed, oxide-associated PO4 from anoxic Central basin sediments clustered around 20‰, and was the only source among our different samples with this elevated signature *Keywords: Phosphorus, Erie, Sediment load, Dead zone, Stable isotopes, Anoxia.*

WATSON, S.B.[1], BOYER, G.L.[2], and HOWELL, T.[3], [1]Environment Canada, National Water Research Institute, Burlington, ON, L7R 4A6; [2]State University of New York, College of Environmental Science and Forestry, Syracuse, NY, 13210; [3]125 Resources Road, Toronto, ON, M9P 3V6. **Long term patterns in taste-odour and toxins in inshore and offshore Lake Ontario.**

Lake Ontario is a drinking water source for over 5 million Canadian and US consumers. The lake has undergone extensive change in the nature and dynamics of nutrient inputs and recycling, as a result of major regime shifts in the foodweb coupled with continued human assaults. This has been manifested in outbreaks of taste and odour (T&O)and toxins which have raised concerns for the integrity of this major sourcewater. Monitoring, intepreting and controlling these impairments is challenging, due to the physical size and complexity of the waterbody and multiple biological signals and sources. We present the first long-term record of taste-odour (geosmin, MIB and b-cyclocitral) and toxins (microcystins, neurotoxins)in the Great Lakes, from samples collected in LAke Ontario inshore and lakewide onitoring between 2000 and 2009, and relate these data to local shoreline influences, nutrient levels and stochiometry and physical processes as a basis for the development of predicitive and scenario-based management models. *Keywords: Lake Ontario, Taste and odour, Algae, Toxins, Impared water use, Nutrients.*

WATTIGNEY, W.A. and DEARWENT, S., Agency for Toxic Sunstances and Disease Registry, 4770 Buford Highway NE MS F-57, Atlanta, GA, 30341, US. **Biomonitoring of Great Lakes populations.**

The Agency for Toxic Substances and Disease Registry (ATSDR), as part of EPA's Great Lakes Restoration Initiative, will conduct a biomonitoring program in the Great Lakes (GLs) region beginning in late 2010. Body burden of persistent toxic substances in the GLs ecosystem will be measured in residents, particularly those who are at high risk of exposure. ATSDR will support and coordinate state-based biomonitoring programs. Proposals will be solicited from state health departments and tribes in the GLs states. Applicants are encouraged to demonstrate partnerships with relevant intrastate agencies, tribes, universities, and public or nonprofit private agencies, institutions, and organizations in their geographic region. Past, current and proposed activities and collaborations that address human exposure to GLs contaminants are an important consideration. Common standardized protocols will ensure consistencies in the sampling of targeted, vulnerable populations, collection and measurement of analytes, and gathering of questionnaire data. However, states can also propose to address specific concerns beyond the core elements. The overall purpose of the program is to provide unique, baseline exposure information to health and environmental officials to help guide actions and measure impacts associated with the restoration process. *Keywords: Assessments, Populations, Biomonitoring.*

WEBSTER, E., ELLIS, D.A., and REID, L.K., Centre for Environmental Modelling and Chemistry (CEMC), Trent University, Peteroborough, ON, K9J7B8. **Modelling the Environmental Fate of PFO(A) in the Lake Ontario Watershed.**

The environmental fate of the perfluorinated conjugate pair, perfluorooctanoic acid (PFOA) and perfluorooctanoate (PFO), in the Lake Ontario watershed is examined through a consideration of the properties and processes pertaining to each species. A multimedia, multi-species, environmental fate, Mackay-type model was developed to assess of the relative contribution of each individual species, in equilibrium with each other, to the overall environmental movement of the pair. Results indicate that in the equilibrated presence of both PFOA and PFO, the environmental fate of the pair is largely predictable from the physical properties of the neutral acid. The anion, the most populous species in the aqueous phase, acts as a source of the neutral acid in the aqueous phase for subsequent partitioning to non-aqueous phases. All local field measurement concentrations of the conjugate pair, PFO(A), are explained by the model to within an order of magnitude, with the exception of lake sediment solids. Initial calculations suggest an atmospheric LRT potential for PFO(A) on the order of thousands of kilometers. Thus not only is local fate explained but concentrations in remote locations may also be explained by the properties of the neutral PFOA when considered in equilibrium with its conjugate base, PFO. *Keywords: Environmental contaminants, Perfluorooctanoate, Mathematical models, Perfluorooctanoic acid, Air-water interfaces, Long-range transport potential.*

WEBSTER, W.C., SCHOCK, N.T., and UZARSKI, D.G., Central Michigan University, Biology Department, Brooks Hall 217, Mount Pleasant, MI, 48859. **Impacts of Great Lakes Water Level Fluctuations on the Macrophyte Flora of Coastal Wetlands through Anthropogenic Disturbance.**

Wetland loss is primarily attributed to anthropogenic disturbances such as dredging and hardening of the shoreline which contribute to the divergence of the natural flow regime leading to the elimination or alteration of wetland vegetation. The Laurentian Great Lakes are subject to natural water fluctuations that are crucial to the biology of the Great Lakes coastal wetlands. These fluctuations promote plant diversity and species richness, which support the health of the Great Lakes coastal wetlands. Natural lake level fluctuations tend to promote development in near shore areas by dredging boat channels during low water level years or hardening the shoreline during high water level years. Wetland structure and function are strongly related to the integrity of the vegetation. Thus, the objective of this study was to determine the affect of anthropogenic disturbance on wetland plant communities. The study was conducted by comparing areas of disturbance with intact coastal wetlands along the Lake Huron shoreline. An inventory of plant taxa and accompanying physical/chemical data were analyzed to relate coastal wetland vegetation to disturbance. *Keywords: Coastal wetlands, Vegetation, Shore protection.*

WEINTRAUB, L.H.[1], FLYNN, A.M.[1], SELVENDIRAN, P.[1], DEPINTO, J.V.[1], and RUPP, B.R.[2], [1]LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108; [2]USACE Buffalo PM-PB, 1776 Niagara Street, Buffalo, NY, 14207. **Watershed Modeling to Support Agricultural Management of Sediment and Nutrient Export from the Blanchard River Watershed.**

The Maumee River Basin contributes an estimated 80% of the suspended solids load to the western basin of Lake Erie. Considerable attention has focused on reducing erosion from this highly agricultural watershed to improve water quality and to reduce the need for maintenance dredging in the river's navigation channel. Funding from the U.S. Army Corps of Engineers 516(e) program supported the application of a watershed model, AnnAGNPS, to the Blanchard River Watershed (771 mi2), one of eight major sub-basins in the Maumee River Basin. AnnAGNPS, provides a continuous simulation of surface runoff, watershed erosion, and nutrient loading. The model distinguishes between erosion from sheet/rill, ephemeral gully, and bank/bed sources. This talk will present the calibration and confirmation of the model to 15 years of observed streamflow, suspended sediment, nitrogen, and phosphorus data. The calibrated model projects potential benefits of various conservation treatment strategies and best management practices. Management scenarios include conversion of agricultural watershed areas to no-till, low-till, or grass buffers; modification of fertilizer practices; and evaluation of tile drainage system impacts. The completed model will be distributed to watershed stakeholders to support watershed management decisions. *Keywords: Nutrients, Sediment control, Watersheds.*

WELCH, D.W., Kintama Research Corp, 10-1850 Northfield Road, Nanaimo, BC, V9S 3B3. **Optimal Design & Operation Of The Pacific Ocean Shelf Tracking Array (POST)- Making Telemetry Array Measurements Cost-Effective & Policy Relevant.**

POST is currently the world's largest fish telemetry system. Here I review POST from the twin perspectives of (a) the broader scientific findings and (b) technical operation & maintenance of a large scale observing system. POST was designed around a particular acoustic tag (the Vemco V9), and detection efficiencies of ca. 95% are possible. However, at least 13 tag variants are now marketed by Vemco, many of which are both smaller and acoustically quieter—which translates into significantly greater cost to achieve the same degree of scientific precision. Thus, as biologists gravitate towards smaller tags, POST requires both a re-design and strong financial justification. Current work is focused on refining operational approaches and designing telemetry arrays with "certified scientific performance" at demonstrably lowest cost. This will allow research studies that can achieve a known accuracy and precision before the study even starts. Work in this area provides the critical benefit of demonstrating that the new designs are "provably best", and therefore provide the best possible economic value and highest scientific data yields. Certified performance will also provide the opportunity to design & conduct explicit experiments in vast water bodies (such as the Great Lakes) to test key management hypotheses. *Keywords: POST, Migrations, Acoustic arrays, Observing systems, OTN, Fish tagging.*

WELLEN, C.[1], LABENCKI, T.[2], BOYD, D.[2], and ARHONDITSIS, G.B.[1], [1]University of Toronto, Toronto, ON; [2]Ontario Ministry of the Environment, Toronto, ON. **Non-Point-Source Impacts on Stream Nutrient Concentrations in the Hamilton Harbour Watershed.**

There is a pronounced trend of conversion of agricultural land uses to urban land uses in the basin of the Great Lakes. Catchments dominated by urban land uses have been found to differ from agricultural ones in both absolute amounts and temporal patterns of nutrient export. While the absolute magnitude of nutrient export is often lesser, nutrient export occurs more

frequently as episodic events. This difference could have ecological implications for receiving waterbodies. This study focuses on the basin of Hamilton Harbour, a small embayment on the western end of Lake Ontario. Correlations between nutrient concentrations and catchment land uses are reported for the subcatchments of Hamilton Harbour's basin. We will also present a number of hydrological indices designed to represent the effects of urbanization on the hydrograph, e.g., the ratio of baseflow to peak flow for an event. Our analysis suggests that the non-point loading levels in the Harbour do not differ significantly from existing estimates, although we did not find any evidence in support of the traditional piecewise monotonic approach between nutrient concentrations and flow. The results will help watershed managers to project the ramifications of future urbanization, and will also suggest hypotheses to test in a subsequent watershed modeling project. *Keywords: Sediment load, Watershed modeling, Nutrients, Non-point sources, Biogeochemistry, Flow.*

WELLS, M.G.[1] and PARKER, S.[2], [1]Department of Physical and Environmental Science, University of Toronto, 1265 Military Trail, Toronto, ON, M1C1A4; [2]Fathom Five National Marine Park and Bruce Peninsula National Park, Parks Canada,, 248 Big Tub Rd., Tobermory, ON, N0H 2R0. **The thermal variability of the waters of Fathom Five National Marine Park, Lake Huron.**

Measurements of the thermal stratification at 3 locations within Fathom Five National Marine Park in Lake Huron, Ontario during the summers of 2006 and 2007 found large oscillations in the position of the thermocline. These oscillations lead to considerable variability in the temperature at a given depth, with frequent changes in temperature at a rate of 5°C per hour, and brief periods where temperatures changed at the rate of 10°C per hour. The thermal stress due to such fast rates of temperature change has been previously implicated in negative effects on many aquatic organisms. The thermocline was observed to move by as much as 20 m vertically, and had dominant periods of oscillation of 12, 17 and 24 hours. The strongest temperature variability occurs in the depth range of 10-20 m, which accounts for 20% of the total lakebed area within Fathom Five. The temperature variability was lowest in deep regions well below the thermocline and at a sheltered area behind a reef. This variability was a ubiquitous feature of the water column of Fathom Five during the summer stratification, and the impact of these frequent short-term thermal fluctuations on benthic and fish habitat is discussed in this talk. *Keywords: Lake Huron.*

WELSH, A.[1], QUESTEL, J.[2], SMITH, R.[1], WALSH, M.[3], BOWEN, K.[4], and SCHANER, T.[5], [1]SUNY-Oswego, Department of Biological Sciences, Oswego, NY, 13126; [2]University of Alaska Fairbanks, School of Fisheries and Ocean Sciences, Fairbanks, AK, 99775; [3]U.S. Geological Survey, Lake Ontario Biological Station, Oswego, NY, 13126; [4]Department of Fisheries and Oceans Canada, Great Lakes Lab for Fisheries & Aquatic Science, Burlington, ON, L7R 4A6; [5]Ontario Ministry of Natural Resources, Lake Ontario Management Unit, Picton, ON, KOK 2T0. **Genetic Determination of the Invasion Pathway of Hemimysis anomala throughout the Great Lakes.**

Hemimysis anomala is a recent invader to the Laurentian Great Lakes and little is known about its North American invasion pathway. Determining whether there have been multiple introductions from different locations can help predict a species' invasion success. We analyzed a portion of the mitochondrial cytochrome oxidase I gene from *H. anomala* samples collected in southern and northern Lake Ontario, Lake Erie, and Lake Huron. In southern Lake Ontario, two haplotypes were identified: A1 and B1. Haplotype B1 was the most common in southern Lake Ontario, with a frequency of 0.59. This population most likely originated from the connecting waters of the Rhine River and the Black Sea. However, Haplotype B1 is less frequent in northern Lake Ontario (0.22) and Lake Erie (0.14). In Lake Huron, Haplotype B1 is the most common (0.6). It appears that individuals from a single location were introduced into the Great Lakes and the genetic differences observed between locations are likely due to the founder effect as *H. anomala* moved throughout the Great Lakes. *Keywords: Invasive species, Genetics.*

WESELOH, D.V.[1] and MOORE, D.J.[2], [1]Canadian Wildlife Service, Environment Canada,, 4905 Dufferin St., Toronto, ON, M3H 5T4; [2]Canadian Wildlife Service, Environment Canada, Box 5050, Burlington, ON, L7R 4A6.
Contaminant Trends in Great Lakes Herring Gulls, 1974-2007.

A long-term annual monitoring project to determine spatial and temporal trends of major environmental contaminants in Great Lakes Herring Gull eggs has been ongoing since 1974. Eggs are collected in late April-early May from 15 gull colonies from throughout the Great Lakes and analyzed, as site pools, for over 75 contaminants. Temporal trends were identified by change-point regression for each site for the years 1986-2007; spatial patterns were identified by ANOVA and SNK tests for data from 2001-2005. Four temporal models were found. Specific contaminants declined: 1) at a constant rate over the duration of the study, 2) faster in more recent years 3) slower in more recent years, or 4) showed no significant trend. At most sites, DDE, dieldrin and HCB declined at a faster rate in recent years; PCBs showed the most models which were declining more slowly and TCDD had the most non-significant trends. Logistic regression on data from 1997-2007 showed that only 5.8% (7 of 120) of the contaminant-site comparisons showed significant regressions (P< 0.001); there has been little significant decline in legacy contaminants in gull eggs in the last decade. Significant spatial patterns were found for all 7 contaminants tested. The greatest concentrations of 4 compounds were found at Channel-Shelter Island, Saginaw Bay, Lake Huron. *Keywords: Herring Gulls, Spatial analysis, Legacy Contaminants, Organochlorine compounds.*

WILEY, M.J.[1], PIJANOWSKI, B.C.[2], HYNDMAN, D.W.[3], and RISENG, C.R.[1], [1]School of Natural Resources & Environment, University of Michigan, Ann Arbor, MI, 48109; [2]Forestry & Natural Resources, Purdue University, West Lafayette, IN; [3]Geology Department, Michigan State University, East Lansing, MI.
Prioritizing restoration and conservation activities in the Muskegon River watershed: a multi-modeling approach.

High resolution mutli-modeling of land cover change, hydrology and resulting ecosystem responses provides a comprehensive platform for spatially explicit prioritization of conservation and restoration activities. In the Muskegon watershed each land unit (tributary sub-basin and

NHD arc shed) has been evaluated for water, sediment, nutrient load output, biological integrity and fishery-relevant habitat value based on inputs of standardized climate and land cover maps. By manipulating land cover distribution, and then iteratively modeling landscape units we can estimate the absolute and relative sensitivity of each unit to various types of land cover change. Essentially we take the derivative of parameter change (e.g. TP load locally or at the river mouth) with respect to upstream land cover change. This generates an estimate of sensitivity to land management manipulation. Coupled with a land cover change projection we then can compute a "priority" value for the unit as the product of its risk of land cover change multiplied by its' sensitivity to that change. This prioritization has already been completed for the main sub watersheds of the Muskegon River and has been used to site initial re-forestation efforts (Fall 2009); and is being used to adjust the priorities in the current Muskegon Watershed Management Plan. *Keywords: Watersheds, Prioritization, Pollution load, Landuse, Model studies, Restoration.*

WILHELM, S.W.[1], FARNSLEY, S.E.[1], DEBRUYN, J.M.[2], LECLEIR, G.R.[1], LAYTON, A.C.[3], QIN, B.[4], ZHU, G.[4], XU, H.[4], OTTEN, T.[5], BOYER, G.L.[6], and PAERL, H.W.[5], [1]Department of Microbiology, The University of Tennessee, Knoxville, TN, 37996; [2]Biosystems Engineering and Soil Science, The University of Tennessee, Knoxville, TN, 37996; [3]Center for Environmental Biotechnology, The University of Tennessee, Knoxville, TN, 37996; [4]State Key Lab of Lake Science and Environment, Nanjing Institute of Georgraphy and Limnology, Chinese Academy of Sciences, Nanjing, 210008, PR China; [5]Institute of Marine Science, University of North Carolina - Chapel Hill, Morehead City, NC, 28557; [6]Department of Chemistry, SUNY College of Environmental Science and Forestry, Syracuse, NY, 13210. **Harmful algal blooms in China's Lake Taihu: A looking glass for other large, eutrophying waters.**

Eutrophication in freshwaters has led to a global proliferation of cyanobacteria which foul water intakes, disrupt foodwebs, fuel hypoxia and produce secondary metabolites that damage and/or are toxic to a variety of consumers. As part of a US-Chinese collaboration, a process-based approach for assessing, controlling and mitigating blooms in China's Lake Taihu is underway. The third largest lake in China and home to >30 million residents within the drainage basin, Taihu has been seriously impacted by recurring *Microcystis* blooms. To understand these blooms nutrient addition and dilution bioassays are being conducted in conjunction with state-of-the-art molecular and chemical examinations of community structure and toxin production. The hypothesis that dual nutrient (N & P) inputs constrain biomass accumulation is being tested. High throughput quantitative and qualitative biomolecular tools are also being used to examine the cyanobacterial community. These tools are also being applied to the bacterial community that co-occurs with blooms to test the secondary hypothesis that blooms act as potential sentinels of for pathogens. A program of research, education and partnership with Chinese researchers will provide a "*looking glass*" to how future cyanobacterial events might be dealt with in North American systems. *Keywords: Microcystis, Lake Taihu, Microbiological studies, Nutrients.*

WILLOX, C.C., ROBILLARD, M.M., and LA ROSE, J.K.L., Aquatic Science Unit, Ministry of Natural Resources, 26465 York rd. 18, Sutton West, On, L0E 1R0.
Current state and temporal trends in the nearshore fish community of Lake Simcoe.

Temporal changes in the nearshore fish community of Lake Simcoe were assessed. Lake Simcoe is a large inland lake in central Ontario. The diverse fish community inhabiting Lake Simcoe is of considerable ecological and economic significance. Patterns in the current status and temporal trends in the catch rate, species composition and biological attributes of warmwater species inhabiting the nearshore habitat in late summer were examined. Data were collected annually, since 1992, using an Ontario provincial standard index netting protocol. Despite the multitude of changes that have occurred in the aquatic ecosystem temporal analysis provided no indication that there has been a long-term directional change in the catch rate of warmwater species during the study period. Although the catch rate of most species, especially black crappie and yellow perch, was highly variable among years, no long-term directional changes were observed in the catch rates of six of the eight species examined. Our analyses highlight the value of long-term lake monitoring programs, which are especially valuable in light of the dramatic ecosystem level changes that will continue to occur in Lake Simcoe. *Keywords: Monitoring, Lake Simcoe, Fish populations.*

WILSON, C., Ontario Ministry of Natural Resources, Trent University, Peterborough, ON, K9J 7B8.
Genetic markers as heritable tags: temporal and spatial tracking of individuals and populations in the Great Lakes.

Genetic marker systems have increasingly been employed as geographic tools for fisheries management. Information on geographic genetic structuring among populations provides essential baseline data for mixed-stock analysis of commercial and recreational fisheries, thereby helping to ensure the sustainability of harvested populations. Other aspects of genetic data are informative for resolving population distribution and habitat use, as well as connectivity among populations and habitats. Combining population- and individual-level genetic analyses with spatial habitat and exploitation information provides valuable insights on spatial pressures and resource use. Examples from current projects on the stock structure analysis of Great Lakes species of commercial significance (walleye, brook trout, lake trout, and muskellunge) will be used to illustrate genetic insights into metapopulation dynamics, habitat fragmentation, and habitat use and linkages for multiple life stages of several fish species. The fusion of mapping genetic structure and diversity alongside land and resource use is helping to provide state of the art decision support tools to help address the unprecedented challenges facing Ontario's aquatic resource managers. *Keywords: Genetics, Fish populations, Habitats.*

WILSON, C.[1], ADDISON, P.[2], CHONG, S.[2], and D'AMELIO, S.[3], [1]Ontario Ministry of Natural Resources, Trent University, Peterborough, ON, K9J 7B8; [2]Ontario Ministry of Natural Resources, Sault Ste. Marie, ON; [3]Trout Unlimited Canada, University of Guelph, Guelph, ON, N1G 2W1.
Regional metapopulation structure of coaster brook trout in northern Lake Superior.

Despite Canada's wealth of freshwater resources, aquatic species in Canada face significant conservation challenges. Coaster brook trout are an unfortunate example of this, having declined from being historically ubiquitous in nearshore environments of Lake Superior to a few isolated remnants today. This study examined the geographic genetic structure and connectivity among lake-dwelling and tributary populations of brook trout in northern and eastern Lake Superior, using genetic analysis of microsatellite DNA genotypes to assess the hierarchical structure and diversity within and among remnant coaster populations in Ontario waters of Lake Superior. The genetic results detected several regional gene pools and showed evidence of both local and long-distance dispersal, and underscore the interdependence of 'coaster' and river-resident fish for maintaining a structured metapopulation of brook trout in the lake basin. *Keywords: Fish populations, Genetics.*

WILSON, I.D. and BOLISETTI, T., 401 Sunset Avenue, Windsor, ON, N9B 3P4. **Optimal Operation of Big Creek Marsh, Ontario.**

Big Creek Marsh located in the south-western corner of Essex County, Ontario is perhaps one of the best remaining examples of this region's pre-European development hydrologic condition. The purpose of this research is to develop the operating rules for the Big Creek Marsh hydrologic system using optimization methods traditionally associated with reservoir operations techniques. The principal constraints include conditions that attempt to mimic the wetlands' pre-development ecosystem. The health of the ecosystem within the marsh is greatly affected by the wetlands water levels which are artificially controlled. Relevant hydrologic components included in the formulation are both natural (evapotranspiration, seepage, precipitation, and stream flow) and anthropogenic processes (dam regulated streamflow and pumping from Lake Erie). The paper presents the results of the optimization model in terms of the operation rules of the controlled hydrological processes, reducing the total costs associated with the optimal management of the marsh, while meeting the ecological, political, and social requirements. *Keywords: Marshes, Optimization, Lake Erie, Hydrologic budget.*

WINTER, J.G., HOWELL, E.T., NAKAMOTO, L., and UTSUMI, K., Water Monitoring and Reporting Section, Environmental Monitoring and Reporting Branch, Ontario Ministry of the Environment, 125 Resources Road, Toronto, ON, M9P 3V6. **Changes in chloride concentrations, nutrients and phytoplankton in nearshore Great Lakes waters over three decades.**

The objective of the Ontario Ministry of the Environment's Great Lakes intakes monitoring programme is to monitor and assess the water quality of the Laurentian Great Lakes nearshore areas and connecting channels, using municipal water treatment plant intakes as collection points. Samples are collected from intakes on Lake Superior (2), on Lake Huron (3), on Lake Erie (5) and on Lake Ontario (7). Over the period from 1976 to 2008, total phosphorus concentrations decreased significantly ($P < 0.05$) at all stations in Lakes Huron and Ontario, and at 3 stations on Lake Erie, whereas total nitrate concentrations increased significantly at most stations in all lakes. Subsets of stations within lakes and between lakes demonstrated temporal coherence or synchrony between time series. Chlorophyll a concentrations and phytoplankton

densities decreased significantly at stations in Lakes Erie and Ontario in relation to nutrient load reductions during the early 1980s, with further notable decreases following the invasion of the lakes by dreissenid mussels during the late 1980s to mid-1990s. In this presentation we will briefly describe overall trends and then focus on 3 of the intakes on Lake Ontario to assess annual and seasonal trends in water quality in more detail, emphasizing the period post-dreissenid mussel invasion. *Keywords: Lake Ontario, Phytoplankton, Eutrophication, Monitoring.*

WITTER, D.L., Dept. of Geology, 221 McGilvrey Hall, Kent State University, Kent, OH, 44242.
Calibration and Validation of Satellite-Derived Chlorophyll-*a* Algorithms for Lake Erie.

Satellite observations of water-leaving radiance can be effective tools for assessing and monitoring water quality parameters that are detectable via their influence on water color. Obtaining quantitative satellite-based estimates of water quality parameters requires development of algorithms that relate water-leaving radiance measured by satellite sensors to in-water properties of interest. While calibration and validation (cal/val) of such algorithms is ideally based on a large, representative set of co-located satellite and in situ observations, in many real-world applications, the number of potential cal/val observations is limited due to the challenges of spatial and temporal co-location and/or poor atmospheric conditions. In this study, criteria for screening satellite observations for inclusion in a cal/val dataset for development of regional chlorophyll-*a* algorithms for Lake Erie are considered. The sensitivity of MODIS observations to geophysical parameters that could reduce the quality of the cal/val dataset is examined. Specific parameters that are considered include proximity to clouds, total cloud cover across the region, and aerosol optical thickness. The objective is to develop a set of screening criteria that could be applied to satellite observations before they are included in a cal/val analysis *Keywords: Remote sensing, Water quality, Lake Erie.*

WONG, F., KURT-KARAKUS, P., and BIDLEMAN, T.F., Centre for Atmospheric Research Experiments, Science and Technology Branch, Environment Canada, 6248 Eighth Line, Egbert, ON, L0L 1N0.
Effect of Aging on the Volatility and Degradation of Brominated Flame Retardants and Organochlorine Pesticides in an Urban Soil from Toronto, Ontario.

As the uses of polybrominated diphenyl ether (PBDEs) are being phased out in many countries, it is expected that soils could become a secondary emission source to the atmosphere. It is also anticipated that the demand for alternative brominated flame retardants (BFRs) will grow, but little is known about their environmental fate in soils. The objectives of this study are to: 1) determine changes in volatility of BFRs and organochlorine pesticides (OCs) in soil over time, 2) determine the degradation rates of BFRs and OCs in soils, including the enantioselective degradation of chiral BFRs. A low organic carbon urban soil from Toronto, ON was spiked with a suite of BFRs and OCs and aged under laboratory condition for 90 days. The volatility of spiked chemicals was investigated using a fugacity meter to measure the soil-air partition coefficient ($K_{SA} = C_{SOIL}/C_{AIR}$). Preliminary results showed that K_{SA} of the some spiked OCs and BFRs increased from Day 10 to 60 and leveled off from Day 60 to 90. This suggests that the volatility of BFRs and OCs decreases over time as the chemicals become more strongly bound to

the soil. Degradation of non-BDE BFRs and α-HCH was evident over 90 days, and was enantioselective for the chiral chemicals. *Keywords: Urban areas, Soil, Pollutants, Brominated flame retardants, Organochlorine compounds.*

WOZNEY, K.M.[1], LISKAUSKAS, A.P.[2], and WILSON, C.C.[1], [1]Ontario Ministry of Natural Resources, 2140 East Bank Drive, Peterborough, ON, K9J 7B8; [2]Ontario Ministry of Natural Resources, 1450 Seventh Avenue East, Owen Sound, ON, N4K 2Z1. **Genetic Structure and Diversity Among Populations of Muskellunge (*Esox masquinongy*) in Lake Huron and Georgian Bay.**

Conservation and management issues related to genetic diversity and stock structure have been largely unexplored in Great Lakes muskellunge (Esox masquinongy). Ten spawning groups in Georgian Bay and Lake Huron (North Channel) were sampled and genotyped with 20 microsatellite DNA markers to assess their spatial structure and diversity, determine the number of genetic groups present, and resolve their ranges and relationships. The microsatellite data showed substantial genetic diversity among wild muskellunge, with good congruence between sampling sites and genetic populations. Individual- and population-based analyses revealed hierarchical population structuring with strong patterns of spawning site fidelity and isolation by distance. Individual assignment tests and pairwise divergences among populations showed extremely low levels of straying among spawning sites and minimal gene flow over historical and contemporary timescales. The results of this study will help inform management options for muskellunge in the Great Lakes, and will also be useful for assessing the effectiveness of ongoing restoration and rehabilitation efforts. *Keywords: Lake Huron, Genetics, Fish.*

WOZNEY, K.M. and WILSON, C.C., Ontario Ministry of Natural Resources, 2140 East Bank Drive, Peterborough, ON, K9J 7B8. **Historical and contemporary genetics of muskellunge (*Esox masquinongy*) in Lake Simcoe: options for restoration.**

The fish community in Lake Simcoe has been significantly impacted by anthropogenic effects for over a century. Muskellunge (Esox masquinongy) were historically abundant in Lake Simcoe, with numbers high enough to support a commercial fishery. The population collapsed in the mid-20th century due to a combination of overharvest, habitat loss, and pike expansion. Supplemental stocking from Great Lakes and Kawartha Lakes sources though the latter half of the 20th century failed to prevent the loss of muskellunge from Lake Simcoe. As part of the recent effort to re-establish muskellunge in the watershed, we assessed the genetic ancestry of the historical Lake Simcoe population using archived scale samples (1960s to 1990s) to resolve its relationship with historical and recent stocking sources. Based on data from 20 microsatellite loci, we found no evidence that the original Lake Simcoe population was derived from Great Lakes ancestry as has been suggested. Rather, the majority of historical muskellunge samples appear to be more closely related to populations in the Kawartha Lakes and Lake Couchiching. These data will help inform ongoing management efforts and options for re-establishing this top predator in Lake Simcoe. *Keywords: Lake Simcoe, Genetics, Fish.*

WRIGHT, E.[1], CONTADOR, E.[2], LUMSDEN, J.S.[2], LORD, S.[3], and STEVENSON, R.M.W.[3], [1]Ontario Ministry of Natural Resources, Fish Culture Section, 300 Water St., Peterborough, ON, K9J 8M5, Canada; [2]Fish Pathology Laboratory, Department of Pathobiology, University of Guelph, Guelph, ON, N1G 2W1, Canada; [3]Dept. of Molecular and Cellular Biology, University of Guelph, Guelph, ON, N1G 2W1, Canada.
An update on fish health in the Canadian Great Lakes.

Since 2005, over half a dozen new infectious agents have been identified that affect fish health in wild or cultured fish for stocking in Ontario. These include viral hemorrhagic septicemia virus, spring viremia of carp virus, koi herpes virus, Chlamydia-like organism, and three as yet unidentified viruses affecting white suckers, Chinook salmon and Atlantic salmon. This talk will provide an update of the status of these agents and their impact on fish culture and health in Ontario. *Keywords: Exotic species, Fish hatcheries, Fish diseases.*

WU, C.H., ANDERSON, J.D., and LIN, Y.T., 1269D Engineering Hall, University of Wisconsin-Madison, Madison, WI, 53706, USA.
Impacts of seichings on bed erosion potential in the Lower Sheboygan River.

Lake seichings of high (.2 ~ 2hr) and low (>2hr) frequencies are common observed in the Lake Michigan. Field data show that the intensity of high frequency seichings can be amplified inside the harbor and estuary, dramatically increasing bottom bed erosion. Lower frequency seichings, not being resonated, can further propagate further river upstream, enhancing turbulence mixing and complicating erosion processes. A coupled hydrodynamic and sediment transport model is developed to assess bed erosion potential under the effects of seichings and flood events in the lower Sheboygan River Estuary in Wisconsin. Results show that during flood events, a combination of high and low frequency waves were significantly elevated, compared with those without seichings. While seichings characteristics (magnitudes) did not exhibit well correlation with the 2, 5, and 25 yr flood recurrence intervals. Effects of high frequency seichings on bed erosion are more important in smaller recurrence interval floods. Lower frequency seichings can further re-distribute sediments, which further complicates the assessment of erosion potential on contaminated sediments. *Keywords: Water level fluctuations, Hydrodynamics, Sediment resuspension.*

WYNNE, T.T.[1], STUMPF, R.P.[1], TOMLINSON, M.C.[1], MANUAR, O.[1], BRIGGS, T.O.[1], NEFF, C.[1], SCHWAB, D.J.[2], DYBLE, J.[2], and LANEROLLE, L.[3], [1]1305 East-West Highway, Silver Spring, MD, 20910; [2]4840 South State Road, Ann Arbor, MI, 48108; [3]1315 East-West Highway, Silver Spring, MD, 20910.
Improvements to NOAA's Demonstrational Harmful Algal Bloom Forecast System in Lake Erie.

NOAA has routinely produced real-time forecasts for cyanobacterial blooms in Lake Erie since 2008. The system incorporates Ocean Color satellite imagery from the MERIS sensor with a 2-D hydrodynamic model from the Great Lakes Coastal Forecasting System. Recent advances to the system will be employed in the summer of 2010. Data will be interpolated from a satellite time series to determine extent and concentration to compensate for clouds and missing data.

Rudimentary modeling techniques will be explored to determine the extent that the bloom will be mixed throughout the water column, and the vertical distribution will be discussed in context of satellite concentration and areal extent of the bloom. Results from the 2008 and 2009 Lake Erie Microcystis spp. blooms will be presented and discussed. As part of the recently created National Harmful Algal Bloom Forecasting System, these forecasts will be switched to an operational capability as early as summer 2011. *Keywords: Microcystis, Monitoring, Remote sensing.*

XIAO, J. and LIAO, Q., Department of Civil Engineering and Mechanics, University of Wisconsin-Milwaukee, Milwaukee, WI, 53211. **A flume experiment of turbulent flow structures over a quagga mussel bed.**

Dreissenid mussels have now become the most well-known invasive species in US and have dramatically changed the ecosystems of most of the invaded waters. In this study, we concentrate on the hydrodynamics of water flows over a Dreissenid mussel bed. For a colonized mussel bed the water motion is responsible for its basic functions, including food delivery, production, respiration, uptake of nutrients, and larval dispersal. Meanwhile the filter-feeding activities may itself introduce turbulent perturbations and interact with the overlying turbulent benthic boundary layer structure. In the presented work, Particle Image Velocimetry has been applied to measure profiles of turbulent flow structures over a quagga mussel bed in a laboratory flume. The measurement comparisons and results shown in this paper directly support the two hypotheses: 1) a mussel bed increases the bottom boundary mixing by both its roughness and filtering activities; 2) the siphonal jets can significantly change the structure of turbulence, such that the log-law is no longer valid for the profile of mean velocity, and the law of wall fails to describe the distribution of dissipation rate. It also shows overall magnitude of 'sweep' events is enhanced as a result of interaction between mussel pumping and the ambient turbulent flow. *Keywords: Mussels, Particle Image Velocimetry, Hydrodynamics.*

YAO, H., Ontario Ministry of Environment, 1026 Bellwood Acres Rd., Dorset, ON, P0A 1E0, Canada. **HYDAM: hydrologically distributed areal model as applied to Muskoka-Haliburton region and its demand for spatial data.**

A tool is needed to provide hydrology information for ungauged streams, explain changes detected from past, and predict future changes and impacts under stressors such as climate change. A distributed hydrology model was developed and calibrated for a study area of 1100 km2 which drains to the Georgian Bay of Lake Huron and includes 8 monitored lake catchments. Daily hydrological processes on each tiny 10mX10m pixel are calculated, and generated runoffs are routed along the flow network connecting all pixels, resulting discharges for any location of interest in the area. The success of the model depends largely on availability and quality of spatially distributed information, such as DEM, soil depth, landcover etc. An initial calibration of the model was achieved by using DEM data from a Land Information Ontario dataset and empirical information from the monitored catchments. The data on soil, geology and vegetation, not yet available, will improve the model's accuracy or performance. For example, an addition of high-quality LIDAR data for three selected catchments has modified the simulation results at these catchments. More spatial data is required to refine model's structure and parameters, which

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demands the advances in geomatics datasets. *Keywords: Hydrologic cycle, Spatial distribution, Model studies.*

YERUBANDI, R., <u>MILNE, J.E.</u>, ROWSELL, R.B., CHARLTON, M.N., MARVIN, C.H., and WATSON, S., Environment Canada, 867 Lakeshore Rd., Burlington, ON, L7R 4A6. **Physical and Water Quality Regimes in Nearshore Western Lake Ontario: 2006 to 2009.**

Environmental data, including water quality, temperature and wind, was collected during the ice-free period from 2006 to 2009 in Western Lake Ontario. Stations were located along a transect starting at the City of Hamilton drinking water intake approximately 1 km offshore to the 30 m depth contour located 6 km offshore. Comparison of temperature and wind data revealed periodic upwellings (westerly winds) and downwellings (easterly winds) which influence water quality near the drinking water intake. Strong downwelling events may have led to moderate to significant taste and odour events in 2006. Analyses revealed water quality results were within acceptable limits. Total Phosphorus and dissolved oxygen were well below the Provincial Water Quality Objectives, however Total Phosphorus and Chlorophyll a showed strong variations due to periodic upwellings or downwellings. This project is designed to assist the City of Hamilton in a decision making process to extend the drinking water intake to avoid adverse water quality and taste and odour conditions. *Keywords: Water currents, Wind currents, Water quality.*

<u>YOUNG, J.D.</u>[1], WINTER, J.G.[1], KELLY, N.E.[2], YAN, N.D.[2], and TUDORANCEA, C.[3], [1]Ministry of the Environment, Sportfish and Biomonitoring Unit, 125 Resources Rd, Toronto, ON, M9P 3V6; [2]York University, 1400 Keele St., Toronto, ON, M3J 1P3; [3]Aquatic Bio-Services, 463 Doon South Dr., Kitchener, ON, N2P 2T6. **Changes in the Zooplankton Community Composition of Lake Simcoe from 1986 to 2007.**

Lake Simcoe has undergone many changes in the past decades, including decreasing phosphorus loads, declines in coldwater fish abundances and invasive species introductions. Zooplankton communities are vulnerable to all of these ecosystem changes, especially the introduction of the zooplanktivore *Bythotrephes longimanus*, which was first detected in Lake Simcoe samples in the autumn of 1993. Zooplankton have been collected in Lake Simcoe since 1986 at 3–12 stations varying in depth from 3 to 42 m. Following the *Bythotrephes* introduction, zooplankton species richness decreased at all stations > 15 m depth, and this decrease was most dramatic for cladocerans. The response of Lake Simcoe zooplankton species to *Bythotrephes*, such as the disappearance of *Holopedium*, was more similar to the Great Lakes than the much smaller Harp Lake. There were some other interesting observations that have not been observed elsewhere. For example, some species have reappeared in recent years, even though *Bythotrephes* remains abundant. Additionally, a loss in zooplankton species richness was delayed at shallow lake stations or did not happen at all. This observation and others will be explored further in this presentation, which will detail both spatial and temporal trends in the Lake Simcoe zooplankton community. *Keywords: Bythotrephes longimanus, Zooplankton, Species diversity, Biological invasions.*

YU, H.[1], JIAO, Y.[1], SU, Z.[2], and REID, K.[3], [1]Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA, 24061-0321; [2]Institute for Fisheries Research, 212 Museums Annex Building, 1109 N. University Ave, Ann Arbor, MI, 48109-1084; [3]Ontario Commercial Fisheries Association, Box 2129, 45 James Street, Blenheim, ON, N0P 1A0. **Performance Comparison of Traditional Sampling Designs and Adaptive Sampling Designs for Fishery-Independent Surveys.**

Fishery-independent surveys play an important role in fish stock assessment. An efficient sampling design is one of the keys to a successful fishery-independent survey. We compared the performance of the traditional sampling designs with adaptive sampling designs, using Lake Erie fishery-independent survey data for yellow perch as an example. Based on the existing survey data (1990 – 2003), yellow perch was observed to be heterogeneously distributed and this heterogeneity varies over time. Adaptive sampling designs are thought to be suitable for surveying heterogeneous populations. Initially, we used bias, mean absolute error (MAE) and variance of the mean of the estimator to compare simple random sampling, stratified random sampling and adaptive two-phase sampling (ATS). ATS was the best design under most situations. We then compared ATS, adaptive cluster sampling (ACS), adaptive two-stage sequential sampling (ATSS), and the currently used sampling design. ATS performed better than the other two approaches and the current sampling design. A simulation study was conducted to compare these designs by examining the accuracy and precision of the estimator. We concluded that for yellow perch, ATS is preferable to the current sampling design of the fishery-independent Lake Erie partnership index fishing survey. *Keywords: Yellow perch, Lake Erie, Fisheries.*

YUILLE, M.J.[1], JOHNSON, T.B.[1], ZHANG, L.M.[2], CAMPBELL, L.[2], ARNOTT, S.[2], BOWEN, K.[3], BROUSSEAU, C.[3], KOOPS, M.[3], and MARTY, J.[4], [1]Ontario Ministry of Natural Resources, 41 Hatchery Lane, RR#4, Picton, ON, K0K 2T0, Canada; [2]Queen's University, 116 Barrie St., Kingston, ON, K7L 3N6, Canada; [3]Fisheries and Oceans Canada, 867 Lakeshore Rd., Burlington, ON, L7R 4A6, Canada; [4]St. Lawrence River Institute of Environmental Sciences, 2 Belmont St.`, Cornwall, ON, K6H 4Z1, Canada. **Eating or competing?** *Hemimysis anomala*: **food web effects in Lake Ontario.**

In 2006 the Ponto-Caspian invader *Hemimysis anomala* was observed at two locations in the Great Lakes basin. Since 2007, a collaborative effort between the Ontario Ministry of Natural Resources and Fisheries and Oceans Canada has documented an increasing density of *H. anomala* from east to west on the northern shore of Lake Ontario. For each season (spring, summer and fall) numerous fish species were sampled from five sites (Port Dalhousie, Bronte, Cobourg, Waupoos and Bay of Quinte), which were chosen across a gradient of *H. anomala* density. 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 nearshore Lake Ontario food web. Examination of fish stomach contents confirmed that *H. anomala* have been incorporated into the Lake Ontario food web and stable isotope and tissue analyses provided further support of dietary and energy flow shifts within the food web. With the use of stable isotopes, food web models will be developed to

determine whether the insertion of *H. anomala* has resulted in trophic shifts within the ecosystem. *Keywords: Stable isotopes, Food chains, Invasive species.*

YULE, D.L.[1], STOCKWELL, J.D.[2], HRABIK, T.R.[3], GORMAN, O.T.[1], KELLY, J.R.[4], YURISTA, P.M.[4], and ISAAC, E.J.[3], [1]USGS, Great Lakes Science Center, Lake Superior Biological Station, 2800 Lakeshore Drive E, Ashland, WI, 54806; [2]Gulf of Maine Research Institute, 350 Commercial Street, Portland, ME, 4101; [3]University of Minnesota - Duluth Biology Department, 207 Swenson Science Building, Duluth, MN, 55812; [4]U.S. EPA - Mid-Continent Ecology Division, 6201 Congdon Boulevard, Duluth, MN, 55804. **Development of an Ecosystem Model for the Lake Superior Offshore Food Web.**

The Great Lakes Fishery Commission is advocating a move towards ecosystem-based fishery management (EBFM) whereby long-term benefits of fisheries are realized without compromising ecosystem integrity. To help evaluate EBMF, we developed an ECOPATH model of the Lake Superior offshore food web. Despite having relatively low biomass, both siscowet lake trout (Salvelinus namycush siscowet) and exotic sea lamprey (Petromyzon marinus) likely play a structuring role in the food web. Current harvest of offshore fishes is limited, extracting only 1% of net primary production. Because Lake Superior supports a highly-developed microbial loop, estimated trophic transfer efficiency (TE) from primary consumers to prey fish was high (>15%) compared to other ecosystems. Estimated TE at higher trophic levels was comparatively low (7-9% to siscowets; 4% to sea lamprey). Balancing the ECOPATH model required high ecotrophic efficiencies for most prey fish, suggesting predation by siscowet is likely intense. This finding is consistent with recent work showing energy density of lean lake trout in nearshore waters is also in decline. Although Lake Superior has a largely intact offshore fish community, ECOPATH ascendency metrics suggest it is vulnerable to perturbations. *Keywords: Fish management, Ecosystem modeling, Lake Superior.*

YURISTA, P.M., KELLY, J.R., MILLER, S.E., and VAN ALSTINE, J., US EPA Midcontinent Ecology Division, 6201 Congdon Blvd., Duluth, MN, 55804. **Lake Ontario: Nearshore Variability.**

Attention to nearshore conditions has increased in recent years. We conducted a high-resolution survey of the Lake Ontario nearshore along the 20 meter contour using towed electronic instrumentation. The 720 km survey was conducted September 6-10, 2008 with a shorter 300 km segment surveyed August 14-15 for comparing temporal variability. Along the survey tracks we also sampled fixed stations (17 and 6 respectively) to collect calibration data and other parameters not observed by the in situ electronic sensors. The towed sensors provided information on spatial variability in the nearshore. Correlation of nearshore data with respect to landscape characteristics of the adjacent coastal watersheds (US only) was analyzed using multivariate stepwise regressions. The strongest correlation to the landscape among the nearshore data was from specific conductivity, beam attenuation and chlorophyll (r2 of 0.50, 0.42 and 0.41 respectively). The survey provides a comprehensive data set for the Lake Ontario nearshore. The survey supported a coordinated effort among US and Canadian agencies to sample Lake Ontario in 2008. *Keywords: Lake Ontario, Coastal ecosystems, Monitoring.*

ZANANSKI, T.J.[1], CRIMMINS, B.[1], HOLSEN, T.[1], and MURPHY, E.[2], [1]Clarkson University, 8 Clarkson Ave, Potsdam, NY, 13699; [2]US EPA Great Lakes National Program Office, Chicago, IL, 60604.
Total Mercury Trends in Top Predator Fish (1999-2008) Determined as part of the Great Lakes Fish Monitoring Program.

The mission of the Great Lakes Fish Monitoring Program (GLFMP) is to assess the ecological health of the Great Lakes ecosystem and determine trends in ecosystem conditions. Two specific objectives of the GLFMP are to monitor temporal trends in bioaccumulative organic chemicals and mercury (Hg) in the Great Lakes using top predator fish as biomonitors, and to assess potential human exposure to organic contaminants and Hg found in these fish. These objectives are met through two elements of the program: Element 1 involves collecting top predator fish (lake trout, *Salvelinus namaycush*, and walleye, *Sander vitreus*) in the open waters of the five Great Lakes and analyzing composites of whole body tissue for contaminants. Element 2 involves collecting samples of sport fish (*Oncorhynchus kisutch, O. tshawytscha*, and *O. mykiss*) and analyzing the skin-on fillet composites to determine whether contaminants are present at levels that could pose risks to human health. In this presentation, our primary focus is on Element 1 Hg trends, with a brief look at Element 2 levels in regard to fish consumption advisories. Trend analysis was done by quadratic and two-segment linear piecewise regressions. Lakes Erie, Michigan and Ontario exhibited decreasing trends, while Huron and Superior showed increasing trends. *Keywords: Mercury, Fish, Environmental contaminants.*

ZARULL, M.A.[1], HARTIG, J.H.[2], CORKUM, L.D.[3], GREEN, N.[4], ELLISON, R.[5], COOK, A.[2], NORWOOD, G.[2], and GREEN, E.[3], [1]Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [2]US Fish and Wildlife Service, 9311 Groh Road, Grosse Ile, MI, 48138; [3]University of Windsor, 401 Sunset Avenue, Windsor, ON, N9B 3P4; [4]Detroit River Canadian Cleanup, 311-360 Fairview Avenue West, Essex, ON, N8M 1Y6; [5]U.S. Environmental Protection Agency, 9311 Groh Road, Grosse Ile, MI, 48138.
Ecological Benefits of Habitat Modification.

Despite substantial loss of habitat in the Detroit River and western Lake Erie, the area remains critically important for migratory and resident fish and wildlife. Although much has been done to restore lost habitats and improve existing conditions, the ecological improvements resulting from these projects, as well as the cumulative effects of these changes have yet to be quantified or evaluated against goals or targets of existing plans or programs. This paper discusses some of the key findings from 12 case studies of habitat modification presented in a recently released State of the Strait Conference Report. The report concludes: quantitative goals and objectives should direct the selection and implementation of habitat restoration and enhancement techniques, and should provide the benchmarks for measuring project success; monitoring efforts need to remain in place for some time as recovery may be slow and adjustments to management actions may be necessary as part of an adaptive management strategy; habitat management remains a fragmented responsibility among many agencies and interests, which is often an obstacle to realizing ecological improvements, recovery, and

sustainability; and knowledge transfer sessions should be convened on a regular basis. *Keywords: Detroit River, Remediation, Habitats.*

ZHANG, H.[1], RUTHERFORD, E.S.[2], MASON, D.M.[2], JOHNSON, T.B.[3], ADAMACK, A.T.[1], ZHU, X.[4], and SCAVIA, D.[5], [1]Cooperative Institute of Limnology and Ecosystems Research, University of Michigan, 4840 S. State Rd., Ann Arbor, MI, 48108; [2]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48108; [3]Ontario Ministry of Natural Resources, 41 Hatchery Lane, Picton, ON, K0K 2T0; [4]University of Windsor, Windsor, ON, N9B 3P4; [5]School of Natural Resouces and Environment, University of Michigan, Ann Arbor, MI, 48105.
Ecosystem Level Assessments of Hypoxia Impacts on the Food Web and Fisheries of Lake Erie.

Hypoxia resulting from anthropogenic eutrophication has long been a problem for Lake Erie. Studies of the sublethal impacts of hypoxia on fishes have focused on individual species consumption, behavior and spatial distributions over short time periods, but the long-term effects on the fish community and its food web are poorly known. We used an ecosystem-based model, Ecopath with Ecosim, to investigate the ecosystem-level impacts of hypoxia on the food web and fisheries in the central basin of Lake Erie, and to explore different scenarios of water quality management. Our model includes 15 fish species, 6 benthic groups, 6 zooplankton groups, 4 algal groups, and 3 detritus groups. We balanced our Ecopath model with data collected in 2005 and calibrated the Ecosim model using data from 1994 to 2005. Our model simulated the population dynamics of many fish species in the ecosystem, e.g., rainbow smelt, gobies, yellow perch, etc, and model simulations indicated that hypoxia decreased yellow perch biomass compared to normoxic conditions. We present quantitative estimates of hypoxia impacts on population dynamics of fish species in Lake Erie and discuss how different water quality management strategies may affect food web structure and function, and fisheries in Lake Erie. *Keywords: Eutrophication, Ecosystem modeling, Lake Erie.*

ZHANG, L.[1], CAMPBELL, L.[1], JOHNSON, T.[2], MICHAEL, Y.[2], and JAKOBI, N.[2], [1]School of Environmental Studies and Department of Biology, Queen's University, Kingston, On, K7L 3N6; [2]Glenora Fisheries Station, Ontario Ministry of Natural Resources, Picton, On, K0K 2T0.
Trophic linkages and potential for contaminant transfer associated with Hemimysis anomola, the latest invader in the Laurentian Great Lakes.

Hemimysis anomola (the bloody red shrimp) is an invasive invertebrate first reported in Lake Ontario in 2006. Literature from their native range (Ponto-Caspian region of eastern Europe) suggests Hemimysis prefer nearshore, warmer waters and have rapid propagation and opportunistic omnivorous feeding habits (detritus, phytoplankton, zooplankton, and insect larvae). Hemimysis in turn are consumed by a variety of fishes. To examine their influence on the food web dynamics and contaminant transfer of today's Lake Ontario, we sampled multiple trophic levels, from algae to piscivorous fish, across a gradient of Hemimysis density in the Canadian waters of Lake Ontario during the spring, summer and fall of 2009. All food web components were analyzed for mercury, stable nitrogen and carbon isotopes. Results showed that Hemimysis has distributed widely in Lake Ontario and their density can exceed 200 individual/

m3. We will discuss the role of Hemimysis in the Lake Ontario food web, clarifying the trophic position of Hemimysis and their potential to influence mercury transfer with other native fishes.

ZHANG, W. and RAO, Y.R., NWRI, Water Science and Technology Directorate, Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6.
Application of a eutrophication model for assessing water quality in Lake Winnipeg.

A eutrophication model using Water Analysis Simulation Program (WASP) has been applied to Lake Winnipeg during the period from 2002 to 2007. The model includes two nutrient cycles (N and P) and three functional phytoplankton groups: non-cyanobacteria (Diatoms and green algae), N-fixing cyanobacteria and non-N-fixing cyanobacteria (harmful cyanobacteria, e.g. *Microcystis*). The model also considers distinct features of the morphological, hydrological, and climate conditions of the South and North Basins. The calibrated and validated results of water quality variables are in good agreement with the observed data of TN, NO_3, NH_4, TP, PO_4, and total chlorophyll-a. The model reproduced qualitative features of phytoplankton communities in space and time, such as cyanobacteria in the North Basin during the late summer and non-cyanobacteria in the South Basin during the spring. The model has been used to examine the response of water quality variables and the potential shift of the phytoplankton structure under the different nutrient loading reduction scenarios. *Keywords: Model studies, Eutrophication, Lake Winnipeg.*

ZHANG, X. and WANIA, F., 1265 Military Trail, Department of Physical and Environmental Sciences, University of Toronto Scarborough, Toronto, ON, M1C1A4, Canada.
Application of Chemical Partitioning Maps to the Characteristic Travel Distance of Organic Contaminants in the Aqueous Environment.

The Characteristics Travel Distance (CTD) has been widely used to quantify the long range transport (LRT) potential of persistent organic pollutants (POPs) in the environment. Previous models characterizing CTD were constructed mainly to quantify the loss of contaminant from the air via air-surface exchange and transformation during LRT. Some POPs are released to the aqueous environment, where air-water exchange, water-sediment exchange and aqueous transformation processes determine how far from sources a contaminant is likely to be found. In this study, we investigate the CTD in aqueous environments by developing a Lagrangian type air-water-sediment model that describes these processes. Using the model, the CTD is calculated for a large number of hypothetical chemicals to construct chemical space maps that display the CTD as a function of various partitioning properties. Besides traditional partitioning maps in the two-dimensional(2D) space defined by KOW and KAW or KOA, we also construct maps in the three-dimensional(3D) space defined by KAW, KOC and KPA. While the 2D chemical space is restricted to neutral chemical, the 3D chemical space is deemed able to overcome this limitation. The possibility of using 3D partitioning maps for screening multi-species chemicals for LRT potential in the aqueous environment will be discussed *Keywords: Chemical partitioning map, Environmental contaminants, Mathematical models, Characteristic travel distance, Assessments, Aqueous environment.*

ZHAO, J.[1], YERUBANDI, R.[1], and WASSENAAR, L.[2], [1]National Water Research Institute, Environment Canada, 867 Lakeshore Rd., Burlington, ON, L7R 4A6; [2]National Hydrology Research Institute, Environment Canada, 11 Innovation Blvd., Saskatoon, SK, S7N 3H5. **Dispersion and Connectivity in Lake Winnipeg from Particle Tracking in a 3-D Hydrodynamic Model.**

A three-dimensional hydrodynamic modeling system (ELCOM, Hodges and Dallimore, 2006) is used to study the circulation and thermal structure in Lake Winnipeg. To assess the model performance, we simulate the circulation and temperature distribution of the lake in 2007 and compare the model results with the observations made in the lake. The model showed considerable skill in reproducing the thermal structure, surface currents and water levels. The modeled currents are used to examine the transport and dispersion of passive tracers, local flushing time, and retention and hydrodynamic connectivity of passive particles in the lake. Simulations using passive tracers qualitatively agreed with the measurements of deuterium in Lake Winnipeg during the study period. *Keywords: Hydrodynamic model, Dispersion, Lake Winnipeg, Connectivity.*

ZHOU, Y.[1], MICHALAK, A.M.[1], SCAVIA, D.[3], and RUCINSKI, D.[3], [1]Department of Civil and Environmental Engineering, The University of Michigan, Ann Arbor, MI, 48109; [2]Department of Atmosphere, Oceanic and Space Sciences, The University of Michigan, Ann Arbor, MI, 48109; [3]School of Natural Resources and Environment, The University of Michigan, Ann Arbor, MI, 48109. **Estimating the History of Hypoxic Spatial Extent in Lake Erie.**

Hypoxia has been observed in the central basin of Lake Erie for many years, but its spatial extent and the impact of various controlling factors are poorly understood due to sparse sampling. We present a geostatistical data fusion approach that combines the limited in situ measurements with remote sensing data that have the potential of informing the distribution of dissolved oxygen. The purpose of this work is to produce an accurate estimate of the spatial extent of the hypoxic region in Lake Erie over the last two decades, and to explore the main factors that explain the interannual variation of the hypoxic extent. Estimates from 1987 to 2007 show that the extent of hypoxia exceeded 7000 km2 in 1987 to 1989, 1997 to 1999, 2003, 2005 and 2007; and was lowest in 1990, 1996, 2002 and 2004. Overall, the hypoxic extent was lowest in the early 1990s. The spatial extent of hypoxia was highest in September for most years, whereas the extent was higher in August in 1990, 1993, 2002 and 2004, which were also the years with low overall hypoxic extent. Furthermore, our preliminary results show that there is little apparent direct relationship between total phosphorous load and hypoxic extent. Ongoing work is exploring the combined effects of nutrient loading together with other factors such as temperature changes and wind strength. *Keywords: Eutrophication, Ecosystem modeling, Spatial analysis, Lake Erie.*

ZHU, B.[1], RUDSTAM, L.G.[2], BROWN, M.[3], GEORGIAN, S.E.[3], KOPCO, J.[2], and BASHAW, B.[3], [1]University of Hartford, Department of Biology, West Hartford, CT, 6117; [2]Cornell University, Department of Natural Resources, Ithaca, NY, 14850; [3]Hobart & William Smith

Colleges, Department of Biology, Geneva, NY, 14456. **Controlling Invasive Aquatic Plant European Frogbit Using Two Management Techniques - Hand Pulling and Shading.**

European frogbit (*Hydrocharis morsus-ranis* L.) is a free-floating aquatic plant that is invasive in North America. It has spread south into the Great Lakes region at a rate of 15.6 km/year since was first introduced to Ottawa in 1932. Since it has the potential to be ecologically and economically costly, it is important to devise an effective management strategy for controlling its spread. Our study was conducted in Oneida Lake, NY to gauge the effectiveness of two direct control methods - hand pulling and shading, and to assess the impact of both methods on a number of water quality parameters. Results showed shading removed 100% European frogbit but there was no significant effectiveness of hand pulling. Both techniques did not affect dissolved oxygen, nitrates, and phosphorus when compared with frogbit infested sites or frogbit free sites, probably due to well mixing of the experiment area. However, both shading and hand pulling improved growth of submerged plants dramatically although the growth was still not comparable to frogbit free sites. Our study suggested both hand pulling and shading could be viable options for controlling and eradicating invasive European frogbit. Hand pulling needs to be conducted more frequently to be effective and shading may be refined in the future to become more environment friendly. *Keywords: Submerged plants, Environmental effects, Management techniques, Invasive species.*

ZIGAH, P.K., MINOR, E.C., and WERNE, J.P., University of Minnesota, Large Lakes Observatory, Duluth, MN, 55812, USA.
Radiocarbon insights into provenance and transformation of carbon in Lake Superior: A lake-wide survey.

We utilized the water-column depth profiles of Δ14C within dissolved inorganic carbon (DIC), dissolved organic carbon (DOC) and particulate organic carbon (POC) to investigate the cycling of organic matter in Lake Superior. Radiocarbon data was obtained from cruises to stations across the lake, covering periods of both stratified and isothermal water-column. During isothermal condition, the radiocarbon signature of POC varies widely from modern to 2800 years before present, and do not appear to be related to sample depth but indicate widespread but localized sediment resuspension. Co-occurring DOC Δ14 C values are much less variable, and with the exception of sample from the mouth of the Ontonagon River are all modern (post-bomb). The DI14C during stratification shows the lake is well ventilated, with a general slight decrease of the radiocarbon signal with depth at the various stations. The DO14C at the Western, Central and Eastern stations show the DOC become older with depth. However, the DO14C at the Northern and Southern stations reveal opposite trend, where the DOC become younger with depth. Our data shows that Lake Superior water column contains "old" organic carbon pools (exhibiting ages of 4 to 14 times the water residence time). *Keywords: Lake Superior, Biogeochemistry, Radiocarbon studies, Carbon cycle.*

ZIMMERMAN, A.P., , Ecology and Evolutionary Biology, University of Toronto, Toronto, ON.
 Henry A. Regier: Afflicter of the comfortable.

The research community is familiar with Henry's science, β-fisheries management he called it. We know, as his Order of Canada citation notes, of his leadership nationally and internationally." He played a similar role as educator, mentor and academic leader within the University. Henry was at the "teach-ins" of the 70s. His Aquatic Macrosystems course exposed generations of students to new ideas and new vocabulary: not just ecology but ekistics, not just ecogenic, but holonocratic. His pathology of ecosystems and ecological therapies inspired; he laid out connections between the degradation of urban form in the Great Lakes Basin and the deterioration of its aquatic ecosystems. He argued for bioregionalism. These ideas resonate in the theses of his graduate students. Henry persistently but gently also tried to educate his colleagues: focus on the interdisciplinary; equity is interpersonal, intergenerational, interjurisdictional and interspecies. He talked networks. He argued for sustainability before it became a meaningless buzzword. Henry took on all comers in pushing his ideas up the University bureaucracy, arguing passionately for change. His last stand as Director of the Institute for Environmental Studies was outstanding.

ZOLTAK, J.M., 4601 Guthrie Dr., Peterborough, ON, K9J 8L5. **The Invasives Tracking System: A Tool for Data Collection and Dissemination in Ontario.**

The Invasives Tracking System (ITS) is a web-based tool developed by the Ontario Federation of Anglers and Hunters in partnership with the Ontario Ministry of Natural Resources, and the Centre for Community Mapping. This tool enables the public, members of the community of practice and policy makers to quickly and easily view regularly updated invasive species distribution data using an interactive mapping interface. In addition, users are able to submit sighting reports of invasive species in Ontario with a high degree of location accuracy, as well as share specific information on prevention, monitoring and control initiatives. This presentation will give an overview of the website, project objectives, and its developing role in a provincial early detection and monitoring network for invasive species. *Keywords: Monitoring, Data storage and retrieval, GIS.*

ZWIERNIK, M.J.[1], KENNEDY, S.W.[2], FARMAHIN, R.[3], BURSIAN, S.J.[1], CRUMP, D.[2], GIESY, J.P.[4], HAHN, M.E.[5], COHEN-BARNHOUSE, A.[1], YANG, Y.[4], and HERVE, J.[3], [1]Michigan State University, Department of Animal Science, East Lansing, MI, 48824; [2]Environment Canada, National Wildlife Research Centre,, Ottawa, ON; [3]University of Ottawa, Department of Biology, Ottawa, ON; [4]University of Saskatchewan, Toxicology Centre, Saskatoon, SK; [5]Woods Hole Oceanographic Institution, Woods Hole, MA, 02543-1052. **Linking Molecular Mechanism of Action to Ecological Risk Assessment – Constructs of the Aryl Hydrocarbon Receptor and Predicting Sensitivity of Avian Species to 'Dioxin-Like' Compounds.**

Complex mixtures of dioxin and dioxin-like compounds (DLC) are frequently contaminants of concern in Great Lakes AOC. Predicting the environmental effects of such complex mixtures is complicated by differences in the sensitivity of species. Our group has been challenged by the hypothesis that the basic mechanisms of action of DLCs at the cellular and sub-cellular level can predict sensitivity in animals, and perhaps, in populations. We are

conducting several studies to determine if it is possible to predict the sensitivity of avian species to the embryotoxic effects of DLCs from a molecular and biochemical understanding of DLC interaction with the aryl hydrocarbon receptor (AHR). A series of laboratory and field studies were conducted including in vitro AHR expression assays, AHR binding assays, AHR ligand-binding domain sequencing of 75 avian species, primary hepatocyte cultures, egg injection studies and collection of field data from avian species exposed to DLCs from the Tittabawassee River area and the Great Lakes of North America. The results indicate that (a) the sensitivity of avian species to DLCs can be predicted from knowledge of differences in the genotypes of the AHR among species and (b) the results can be used to guide and direct more accurate environmental risk and hazard assessments. *Keywords: Pollutants, Risk assessment, Genetics.*

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