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ABDELOUAHAB, N.¹, MERGLER, D.¹, TAKSER, L.², VANIER, C.¹, ST-JEAN, M.¹, BALDWIN, M.¹, SPEAR, P.A.³, and CHAN, H.M.⁴, ¹CINBIOSE, Université du Québec à Montréal (UQÀM), Montreal, QC, H3C 3P8, Canada; ²Centre TOXEN, Université du Québec à Montréal (UQÀM), Montreal, QC, H3C 3P8, Canada; ³Département Obstétrique Gynécologie, Université de Sherbrooke, Sherbrooke, QC, J1H 5N4, Canada; ⁴University of British Columbia, British Columbia, Canada. Gender Differences in the Effects of Organochlorines, Mercury, and Lead on Thyroid Hormone Levels in Lakeside Communities of Quebec (Canada).

Environmental chemicals can disrupt thyroid hormone (TH) homeostasis. However studies differ with respect to thyroid profile changes and gender differences are rarely examined. This study investigated the THs in relation to serum organochlorines (OCs), bioindicators of mercury (Hg) and blood lead (Pb) in 211 freshwater fish consumers in Canada. THs were within the normal range and the bioindicators of exposure were low compared to other reports on fish consumers. Stratified analysis showed significant gender differences. For women, serum T3 levels were negatively related to serum concentrations of PCB-138, PCB-153, non-coplanar congeners, Arochlor 1260, and ΣPCB, as well as p,p'-DDE. No relations were observed between T4 and any of the chemicals measured, but TSH was negatively related to blood Pb. For men, serum T4 was inversely related to PCB 138, dioxin-like PCBs and ΣPCB. A significant positive relation was observed between serum TSH and PCB 180, non coplanar congeners, mono-ortho coplanar congeners, dioxin-like PCBs as well as ΣPCB. Serum TSH increased with hair and blood Hg concentrations. No associations were observed for T3 in men. These findings suggest that even at low concentrations, these environmental contaminants can interfere with thyroid status and effects differ by gender. Keywords: Bioindicators, Human health, PCBs.

ADAMS, J.M.¹, HINCHHEY, E.K.¹, HORVATIN, P.J.², and WARREN, G.J.², ¹Illinois-Indiana Sea Grant College Program, Purdue University, Liaison to U.S. EPA GLNPO, 77 W. Jackson Blvd., G-17J, Chicago, IL, 60604; ²U.S. Environmental Protection Agency Great Lakes National Program Office (GLNPO), 77 W. Jackson Blvd., G-17J, Chicago, IL, 60604. U.S. EPA Great Lakes National Program Office Nearshore Monitoring Using the Triaxus Towed Instrument Platform.

Nearshore monitoring is an important factor in assessing the ecosystem health of the Great Lakes, but it often presents a challenge due to the limited availability of research vessels and difficulty in surveying the extensive (>10,000 miles) shoreline. The U.S. EPA Great Lakes National Program Office (GLNPO) recently acquired a Triaxus 3D towed undulating vehicle that will be deployed from the R/V Lake Guardian in all five Great Lakes in waters as shallow as 20 m to gain more insight into nearshore water quality and habitat characteristics. This state of the art towed instrument platform will provide real-time multiparameter profile data of the nearshore water column over a large shoreline distance as well as supplement the GLNPO open water surveys. Details of the Triaxus specifications, the various sensors it will house, and preliminary sampling locations will be presented. Keywords: Monitoring, Habitats, Water quality.
ADLERSTEIN, S.A.\textsuperscript{1}, NALEPA, T.F.\textsuperscript{2}, and VANDERPLOEG, H.A.\textsuperscript{2}, \textsuperscript{1}3010 Dana Building, 440 Church St., Ann Arbor, MI, 48109-1041; \textsuperscript{2}2205 Commonwealth Blvd., Ann Arbor, MI, 48105-2945. \textbf{Zebra Mussel Impacts on the Lower Food Web in Saginaw Bay, Lake Huron: 1990-1996.}

We characterized temporal-spatial trends in phytoplankton, zooplankton, and benthos in Saginaw Bay prior to zebra mussel invasion, over peak densities and stabilization. We used density data of main taxonomic groups quantified during a bay-wide NOAA-Great Lakes Environmental Research Laboratories monitoring program and generalized linear models. Zebra mussels were first found in 1991, reached peaks from 1992 to 1994 depending on location, and later remained at more stable levels. Densities were higher in stations with harder substrates. Phytoplankton and zooplankton declined uniformly within the bay consistent with the zebra mussel invasion. Densities of all phytoplankton groups declined starting in 1991 or within the next three years. The most immediate and noticeable decrease was for cyanophytes with disappearance of photosensitive species. Densities recovered during the study period except for cyanophytes and chlorophytes. All zooplankton groups declined after 1990 and showed some recovery. While cyclopoids and cladocerans exhibited lowest densities in 1993, calanoids and rotifers continued to decline until 1995. Macroinvertebrate trends differed by group and substrate, and mussel effects are harder to demonstrate. Results are invaluable to understand invasion responses at the ecosystem levels and to design future monitoring. \textit{Keywords: Exotic species, Zooplankton, Lake Huron.}

AHMED, S. and TROY, C.D., 550 Stadium Mall Dr., West Lafayette, IN, 47907-2051, United States. \textbf{Hydrodynamic Modeling of Large Stratified Lakes.}

An unstructured, three dimensional, finite volume, non-hydrostatic numerical model is being adapted to study wind- and thermal-forced circulation in lakes. We apply the modified model to the idealized case of an unsteady, wind-forced, stratified large circular lake, following the test case of Beletsky \textit{et al.} (\textit{J. Phys. Ocean.} 1997). The hydrodynamic code, SUNTANS (Stanford Unstructured Nonhydrostatic Terrain Adaptive Navier-Stokes Simulator), uses a z-level coordinate system and adaptive mesh refinement, and has been used successfully elsewhere in the simulation of stratified coastal flows. We apply the model in a parallelized configuration for a range of horizontal and vertical resolutions, discussing the results in the context of planned Lake Michigan simulations that will highlight circulation patterns and thermal features along the Indiana-Illinois lakeshore. \textit{Keywords: Atmosphere-lake interaction, Hydrodynamics, Hydrodynamic model.}

ALLENDER, C.J. and WILHELM, S.W., Department of Microbiology, The University of Tennessee, Knoxville, TN, 37996. \textbf{Identifying the Source of Unknown Microcystin Genes and Predicting Microcystin Variants by Linking Multi-gene Diversity within Uncultured Individual Cyanobacteria.}

While multiple phylogenetic markers have been used to study microcystin producing cyanobacteria, in only a few instances have multiple markers been studied within individual cells, and in all cases these have been cultured isolates. Linking genes along individual microcystin (mcy) synthetase operons from uncultured cells would allow for the prediction of toxin variants and provide a better
diagnostic for species identity. Because of the inability to cultivate many microcystin-producers, it was imperative to develop these culture-independent methods. We employed a long-PCR method and lambda vector cloning to isolate large DNA fragments (>6 kb) encompassing both mcyA2 and mcyB1 gene regions. Using a combination of phylogenetic analyses and bioinformatic prediction, the condensation domain of mcyA2 and the adenylation domain of mcyB1 were examined. These data allowed for the comparison of individual uncultured cells to the database of partial mcyA gene sequences as a query of diversity among microcystin-producers while simultaneously predicting microcystin variants. Initial efforts have been to predict the toxins produced by a mcyA-genotype termed “Microcystis-like” that is pervasive in Lakes Erie and Ontario. Preliminary results have suggested that at least a portion of these organisms produce the LR variant of microcystin. 

**Keywords:** Microcystis, Genetics, Great Lakes basin.

ANDERSON, E.J.1, SCHWAB, D.J.1, HOLTSCHLAG, D.J.2, and LANG, G.A.1, 1NOAA-Great Lakes Environmental Research Laboratory, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105; 2USGS - Michigan Water Science Center, 6520 Mercantile Way, Lansing, MI, 48911. 

**An Operational 2-Dimensional Hydrodynamic Model of the St. Clair-Detroit River Waterway: Implementation into the Great Lakes Forecasting System (GLFS).**

A Computational model has been created for the St. Clair-Detroit River Waterway connecting Lake Huron and Lake Erie. The two-dimensional (RMA2) unstructured model was developed (Holtschlag 2002) to predict water levels and flow velocities in the system, and is now linked with the Great Lakes Forecasting System (GLFS) in order to provide operational nowcasting and forecasting. Water levels near the Huron-St. Clair River and Erie-Detroit River mouths in conjunction with wind forcing data from Lake St. Clair are used to drive the model for both hindcast and nowcast simulations, where lake levels from GLFS predictions are used in order to provide system forecasts. Water levels are compared to observed data from 10 NOAA gage stations located along the St. Clair-Detroit River waterway. Calibration to water level boundary conditions with these stations as well as adjustments to Manning’s-n roughness parameters within the system bring level predictions to within 2 cm of recorded gage station water levels for nowcast and monthly hindcasts. Improvements to prediction accuracy and resolution of complex flow areas in the St. Clair-Detroit River waterway enhance understanding of the physical processes in the system and allow for operational implementation within the GLFS. **Keywords:** St. Clair River, Lake St. Clair, Hydrodynamic model.

ARCAGNI, M.1, ARRIBÉRE, M.1, CAMPBELL, L.M.2, KYSER, K.3, KLASSEN, K.3, and RIBEIRO GUEVARA, S.1, 1Laboratorio de Análisis por Activación Neutrónica, Centro Atómico Bariloche, Bariloche, Argentina; 2School of Environmental Studies, Queen's University, Kingston; 3Department of Geology & Geological Engineering, Queen's University, Kingston. 

**The Role of Native Galaxias maculatus in a Food Web with Introduced North American Salmonids (Nahuel Huapi National Park, Argentina).**

The diet of the native fish Galaxias maculatus (“small puyen”) was studied in Lake Moreno, a satellite of Argentina’s largest lake, Lake Nahuel Huapi watershed. G. maculatus is a common species across Oceania and lower South America. The lakes of Nahuel Huapi National Park have been
significantly impacted by introduced salmonid species, including brown, rainbow, and brook trout. Stable C and N isotopes for *G. maculatus* and selected food items were determined on a seasonal basis in the west and east basins of the hour-glass shaped lake. δ¹⁵N values were higher in the east basin for all species, suggesting a higher trophic position or nitrogen enrichment due to the topography, which exhibits sharp coasts, depths higher than 100 m, and limited littoral areas of rocky bottoms with poor aquatic vegetation. On the other hand, the western basin has shallow bays with organic sediments and highly productive aquatic vegetation. All benthic food items analyzed in the western basin showed similar δ¹³C but smaller δ¹⁵N values, showing that according to SI analysis, puyen have the highest trophic level within the nearshore littoral food web, and may be important prey items for the introduced salmonid species in Lake Moreno in both western and eastern basins. **Keywords:** Stable isotopes, Benthos, Food chains.

ARHONDITSIS, G.B., University of Toronto, Department of Physical & Environmental Sciences, Toronto, ON, M1C 1A4. **Effects of Climate Change on Freshwater Ecosystem Dynamics.**

Climate variability is increasingly recognized as an important regulatory factor, capable of influencing the structural properties of aquatic ecosystems. Lakes appear to be particularly sensitive to the ecological impacts of climate change, and several long time-series have shown a close coupling between climate, lake thermal properties and individual organism physiology, population abundance, community structure, and food-web dynamics. This study presents a statistical analysis of a long-term limnological record from Lake Washington. It is shown that Lake Washington has experienced a warming trend, with overall increase of 1.5°C for epilimnetic temperature. This warming trend is greatest for the period from April to September and is positively correlated with interannual variability in air temperature and the Pacific Decadal Oscillation (PDO). These results are the first to demonstrate strong PDO effects on the thermal properties of a lacustrine ecosystem. There is also evidence for climate-induced changes on the magnitude of the spring bloom/timing of the clear water phase, the coupling of the trophic interactions between phytoplankton and zooplankton, the interspecific niche differentiation, and the sockeye salmon (*Oncorhynchus nerka*) behavioral patterns. **Keywords:** Climate change, Ecosystem modeling, Water quality.

ATILLA, N.¹, BENNINGTON, V.¹, KIMURA, N.¹, MCKINLEY, G.A.¹, URBAN, N.R.², WU, C.H.³, and DESAI, A.¹, ¹University of Wisconsin-Madison, Center for Climate Research, Madison, WI, 53706; ²Michigan Technological University, Civil and Environmental Engineering, Houghton, MI, 49931; ³University of Wisconsin-Madison, Civil and Environmental Engineering, Madison, WI, 53706. **The Carbon Budget of Lake Superior: First Results from the CyCLes Project.**

CO₂ emissions and seasonal cycling from the Great Lakes may be comparable to that of local terrestrial ecosystems. CO₂ fluxes from Lake Superior are of particular interest because they may greatly impact observations at nearby Ameriflux towers. Long residence time of water and limited watershed inputs suggest carbon cycling in Lake Superior is tightly coupled with physical processes. We developed a coupled ecosystem-carbon-hydrodynamic model of Lake Superior to estimate carbon fluxes and their spatio-temporal variations. The ecosystem, including two sizes of phytoplankton, macronutrients, and a
single grazer, is implemented to estimate spatio-temporal patterns of carbon cycling in the lake. Carbon as DOC, DIC, and POC, and O₂ (as an indicator of biological productivity) are included as state variables upon which ecosystem processes act. Model predicted chlorophyll concentrations will be compared with results of synoptic surveys made in 2006. Spatial and temporal patterns of chlorophyll, pCO₂, and CO₂ fluxes as predicted by the model will be summarized in this talk. These patterns will be used to illustrate some of the factors controlling carbon cycling (temperature, watershed inputs), some influences of human activities (e.g., high nutrient inputs in the western basin) Keywords: Lake Superior, Carbon cycle, Modeling.

ATKINSON, J.F., Great Lakes Program, University at Buffalo, Buffalo, NY, 14260. Particle Tracking Applications to Link Physical and Biogeochemical Transport.

Particle tracking applications are presented for three problem domains related to Great Lakes issues: (a) tracking algae blooms; (b) defining resource sheds; and (c) modeling sediment transport. In each case the particle tracking model is based on a random walk algorithm that incorporates velocities and diffusivities produced by a hydrodynamic model. For the first two examples the particles are neutrally buoyant and non-reactive and the Princeton Ocean Model (POM) is used to calculate the hydrodynamic variables. Applications in Lakes Erie and Ontario are shown. For the third case the particles have mass, settle and interact with the bottom, and particle movements are driven by the Estuarine, Coastal and Ocean Model (ECOM). This model is applied in the Buffalo River (Buffalo, NY). Various issues involved with linking the particle tracking and hydrodynamic models, such as grid size, are discussed and it is shown that particle tracking provides a useful tool for understanding circulation and quantifying transport properties in a lake or stream. A unique web application also is demonstrated for real-time applications of the model. Keywords: Water currents, Distribution patterns, Coastal ecosystems.

AUSTIN, J.A., Large Lakes Observatory, University of Minnesota, Duluth, Duluth, MN, 55812, USA. Observed Increases in Wind Speed over Lake Superior.

Observed wind speeds over open water in Lake Superior (and the other northern Great Lakes) observed at NOAA NDBC buoys have increased by about 25% over the period 1980-2007. The increase in wind speed is independent of direction and roughly spatially uniform over Lake Superior. These increases are greatest in the summer months but are observed in all seasons. Wind speeds recorded at coastal (CMAN) stations also show increases, though these increases are weaker than those observed over the open lake. We speculate that this increase may be due to increases in surface water temperatures in excess of the increase in air temperature, which may be leading to a less stable atmospheric boundary layer. Consequences of this increase in wind speed include deeper mixed-layers and increased evaporation rates, which may in turn be responsible for a long-term trend toward lower water levels. Keywords: Climate change, Atmosphere-lake interaction, Lake Superior.

BACH, C.A., 5 Shoreham Dr., Downsview, ON, M3N 1S4. Toronto Waterfront Aquatic Habitat Restoration Strategy.
The Greater Toronto Area occupies an extensive length of the coast of Lake Ontario. Historically, the shoreline and lands were used for commercial purposes with some areas for recreation. Degradation has led to substantive losses of important aquatic habitat. Recently, renewed interest in revitalizing the waterfront has emerged. Significant efforts to revitalize the waterfront require effective coordination at all levels of government. Aquatic Habitat Toronto has been created to implement the Toronto Waterfront Aquatic Habitat Restoration Strategy and coordinate all three levels of government so that projects can be implemented in a timely and cost-effective manner. This presentation will showcase the planning process involving consensus-based development of aquatic habitat on the Toronto waterfront. The objective is to provide an overview of the research, monitoring, planning and ultimately implementation with respect to aquatic habitat within the highly urbanized Greater Toronto Area. 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 “no net loss” policy for development on the waterfront. 

Keywords: Management, Habitats, Planning.


Managing growth and mitigating agriculture are significant challenges encountered when trying to protect and sustain our water resources. This is the case in the Lake Simcoe basin where continued growth combined with impacts from existing agricultural have accelerated the natural eutrophication process. Inputs of phosphorus have tripled since European settlement in the late 1700’s. While significant progress has been realized, increased demands for continued development within the watershed have resulted in a wide range of concern from stakeholders that the protection of the lake is at risk. To address these concerns the Lake Simcoe Conservation Authority undertook an Assimilative Capacity Study for Lake Simcoe basin. The goal of the study was to develop a framework whereby proposed changes to land use could be evaluated based on their impact on water quality relative to water quality targets. Land use decisions could then be made ensuring that the potential to impact water quality conditions would not impact the health of aquatic communities and Lake Simcoe. This paper documents the process and results of the study conducted to quantify current and likely future sources of phosphorus, develop load targets, and outlines the mechanism for managing growth within the basin to achieve and maintain the phosphorus target. Keywords: Water quality, Planning, Lake Simcoe.

BALDWIN, R.J., BAKER, K., and HENSHAW, B., 120 Bayview Pkwy., Newmarket, ON, L3Y 3W3; 8 Main St. N., Markham, ON, L3P 1X2. Natural Heritage Planning in the Lake Simcoe Basin – A Foundation for Science, Research, and Planning.

A case study on natural heritage planning using an existing policy structure. In Ontario, the Provincial Policy Statement (PPS) guides land use planning, including natural heritage. The PPS, under the Planning Act, provides the legislative framework within which municipalities must adhere to when considering land use changes and development. The PPS further prohibits/restricts development from:
significant woodlands, significant valleylands, significant wildlife habitat, Areas of Natural and Scientific Interest (ANSIs), and fish habitat. Lacking in expertise, budget, and incentive, municipalities have failed (since 1999) to identify and designate, and thereby protect, these features. As a principal review the Lake Simcoe Region Conservation Authority opted to identify a natural heritage system, comprised of the features identified in the PPS, on behalf of their municipal partners. This is the first time that all PPS features have been identified as part of a natural heritage system for adoption by municipal Official Plans in the Province. Keywords: Lake Simcoe, Planning, Habitats.


Walleye \textit{Sander vitreus} is one of the most exploited fish species in the lower Great Lakes, and understanding the genetic basis for its stock structure is critically important for fisheries management. Our laboratory research using nuclear DNA microsatellite loci and mtDNA data has shown that most spawning groups in Lake Erie genetically differ due to spawning site philopatry. The present study thus tests whether spawning groups are temporally stable, using 10 Lake Erie spawning sites over a 12 year period (1995-2006) for 10 nuclear microsatellite loci. Samples from the Maumee River, the largest walleye spawning group, from 1995 (N=50), 1998 (N=28), 2003 (N=76), and 2006 (N=51) showed no significant temporal differences indicating a common gene pool in all except the 2003 samples, demonstrating that genetic structure was generally consistent. The 2003 run had more gene flow among sites along the southern Lake Erie shore and constituted the largest recruitment year in past decades. We are comparing this Maumee River spawning site baseline with those from the Sandusky River and Van Buren Bay, which also showed high gene flow in 2003. Our study illustrates the importance of testing temporal patterns of genetic variation (rather than a single year “snapshot”) to understand stock structure. Keywords: Lake Erie, Genetics, Walleye.

BARBIERO, R.P.\textsuperscript{1}, ROCKWELL, D.C.\textsuperscript{2}, WARREN, G.J.\textsuperscript{2}, and TUCHMAN, M.L.\textsuperscript{2}, \textsuperscript{1}Computer Sciences Corporation, 1359 W. Elmdale Ave. #2, Chicago, IL, 60660; \textsuperscript{2}USEPA Great Lakes National Program Office, 77 W. Jackson Boulevard, Chicago, IL, 60604. An Overview of Possible Dreissenid Impacts in the Offshore Waters of the Great Lakes.

The EPA’s Great Lakes National Program Office has conducted regular monitoring of the offshore waters of the Great Lakes since 1983, five years before the discovery of dreissenids in the Great Lakes. During this time, all four lakes supporting dreissenid populations have experienced changes potentially linked to the invasion. In Lake Erie, spring transparency has decreased in both the western and central basins, perhaps due to dreissenid repackaging of particulates into more readily suspended material, while spring transparency in the eastern basin has increased substantially. Spring phytoplankton populations have declined in the western and eastern basins, and communities have shifted notably in all three basins. While there are some indications of increases in spring transparency in the open waters of central Lake Ontario, the main dreissenid impact in that lake has been a dramatic increase in summer transparency, apparently due to calcium uptake by dreissenids and a consequent reduction in whiting events. In Lakes Michigan and Huron, increases in spring Secchi depth have coincided with the recent expansion of
Dreissena bugensis populations into deeper waters, although these increases in water clarity could also be the result, in part, of continued reductions in nutrient loading to those lakes. Keywords: Phytoplankton, Turbidity, Dreissena.

BELETSKY, D.¹, SCHWAB, D.J.², and MCCORMICK, M.J.², ¹University of Michigan, Ann Arbor, MI; ²NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI. **Nested Grid Circulation Modeling in Southern Lake Michigan.**

A nested grid version of the Princeton Ocean Model for the Great Lakes was applied to the coastal area in southern Lake Michigan. The model uses 3D boundary conditions derived from the whole-lake hydrodynamic model to simulate circulation in a small coastal area at very high (100 m) horizontal resolution in 2005. Model results are tested with current observations and data from tracer release experiment in the vicinity of Burns Ditch, Indiana. This tributary to Lake Michigan is known to contain high levels of coliform bacteria and is adjacent to the Indiana Dunes National Lakeshore. In the tracer experiment, the inert gas sulfur hexafluoride was introduced into the tributary and the plume was tracked using a shipboard-based gas chromatography system for several days after the release, and also with a 3D particle transport model applied during the same period. Keywords: Hydrodynamic model, Lake Michigan.

BELETSKY, D.¹ and SCHWAB, D.J.², ¹University of Michigan, Ann Arbor, MI; ²NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI. **Modeling Thermal Structure in Lake Erie.**

A 1D version of the Princeton Ocean Model was applied to Lake Erie to model vertical thermal structure in 1972-2005. The model is driven with momentum and heat fluxes calculated from standard meteorological observations at Cleveland using overland-overlake correction for wind speed. The model was calibrated with 1994 data and evaluated with 2004-2005 temperature observations at mid-lake location. The model was also run in 3D mode for 2005 on a 2 km horizontal grid. 3D model results were compared with 1D model results to assess how lateral processes affect stratification and also how stratification varies spatially over the central basin, and how lateral processes limit (or impact) the use of 1-d model approximations.

BENNINGTON, V.¹, KIMURA, N.¹, MCKINLEY, G.A.¹, WU, C.H.², ATILLA, N.¹, and URBAN, N.R.³, ¹University of Wisconsin–Madison, Atmospheric and Oceanic Sciences, Madison, WI, 53706; ²University of Wisconsin–Madison, Civil and Environmental Engineering, Madison, WI, 53706; ³Michigan Technological University, Civil and Environmental Engineering, Houghton, MI, 49931. **Climate Impacts on the Circulation and Thermal Structure in Lake Superior.**

A three-dimensional hydrodynamic model is applied to Lake Superior on 2 km and 10 km grids to study the circulation and thermal structure. The model is forced by interpolated meteorological data constructed from land-based weather stations, buoys, and other measurements. Observations of temperature profiles at 19 moorings are used to test the sensitivity of vertical grid resolution and different
turbulence mixing closures in the model. The thermal profile is best modeled using a 5-m vertical grid resolution near the surface, but different turbulence closures do not significantly change the modeled thermal profile. Increasing horizontal resolution from 10 km to 2 km improves the seasonally and depth averaged circulation patterns compared to 1967 summer data. Modeled surface temperatures compare well to satellite-based surface water temperature images derived from NOAA AVHRR (Advanced Very High Resolution Radiometer), though there are regional patterns of bias that suggest errors in the heat flux forcing. Adding terms for cooling of the lake surface through the latent heat loss during ice breakup improves model-data comparisons. We consider results from an El Niño and a La Niña year to consider the effects of climate variability on lake circulation and temperature structure. Keywords: Hydrodynamic model, Lake Superior, Climate change.


Blooms of Cladophora sp. in Lake Michigan have obvious effects on aesthetics, but only more recently has their role in nutrient cycling been considered, e.g., their involvement with dreissenid mussels in the “nearshore shunt” of phosphorus. We investigated whether Cladophora and its dense communities of epiphytic diatoms could also be a significant sink for silicate. Cladophora was collected over two summers from sites near Milwaukee, and biogenic silicate (BSi) in the algae and dissolved silicate (DSi) in overlying waters were measured. Cladophora with epiphytes averaged a remarkable 166 ± 68 mg BSi /g dry mass, but even Cladophora lacking epiphytes contained >50 mg/g. DSi in the nearshore was often lower and much more variable than offshore, suggesting a nearshore sink for Si. Using estimates of Cladophora coverage from aerial photos, and biomass and BSi from samplings, we modeled DSi use by benthic algae in the nearshore region. Daily Si demand of Cladophora assemblages represented 7 - 70% of dissolved Si in overlying nearshore waters. This significant but previously unrecognized Si pool could therefore significantly change the Lake Michigan silica cycle, affecting other Si-requiring organisms (e.g., pelagic diatoms) in nearshore waters, during periods of calm weather. Keywords: Nutrients, Cladophora, Biogeochemistry.


Lake Simcoe receives the greatest angling pressure of any Ontario inland lake, with an estimated fishing effort of approximately 702,000 angler hours resulting in over 781,000 catches in the 2005 winter fishery alone. Annual recreational activities on the lake generate approximately 200 million dollars, with the fishery as the main contributor. However, consumption advisories are issued for large sizes of many fish species found in the lake because of high levels of persistent toxic chemicals such as polychlorinated biphenyls (PCBs) and mercury. Long-term trends of contaminants in sport fish can be useful in assessing the health of Lake Simcoe and in constructing future management plans. The data collected by the Sport Fish Contaminant Monitoring Program of the Ontario Ministry of the Environment show that PCB levels are generally much lower compared to the levels in the 1970s; however, the decline has ceased since the
early 1990s. In contrast, mercury levels are stable or show a weak decline over the last 30 years. Concentrations of some pesticides (e.g., Chlordane, Hexachlorocyclohexane (HCH)) have also declined. Total dichlorodiphenyltrichloroethane (DDT) concentrations were elevated in the late 1970s, but declined in the early 1980s. Since that time, the levels have remained relatively low and stable.

Keywords: Biomonitoring, Environmental contaminants, Fish.

BIDDANDA, B.A. 1, KENDALL, S.T. 1, SANDERS, T.G. 1, and NOLD, S.C. 2, 1Annis Water Resources Institute, Grand Valley State University, Muskegon, MI, 49441; 2Biology Department, University of Wisconsin-Stout, Menomonie, WI, 54751. Submerged Sinkhole Ecosystems of Lake Huron: Insights into System Metabolism.

Dissolution of Silurian-Devonian aquifer in the Lake Huron basin has produced several limestone karst formations in the bedrock, through which groundwater containing high dissolved sulfate and extremely low dissolved oxygen discharges onto the Lake Huron floor. This supports unique underwater habitats having steep environmental gradients and prolific benthic cyanobacterial mats. Earlier ROV and diver led studies of some recently discovered Lake Huron sinkholes in western Lake Huron showed them to be microbiually dominated biogeochemical hotspots of intense photosynthetic and chemosynthetic production of organic matter. New continuous in situ sonde measurements of dissolved sulfate and oxygen in water and benthic chambers suggest that whereas shallow sunlit sinkholes are clearly photosynthesis dominated, they give way to chemosynthesis dominated deeper aphotic sinkholes. Intermediate depth sinkholes appear to be fueled by both photosynthesis and anoxygenic photosynthesis taking place in the purple cyanobacterial mats. Additional data from pigment composition, molecular fingerprints, stable isotope probing, 13C, 15N, and 34S signatures, dissolved oxygen metabolism, and radiolabelling experiments will be analyzed to provide insights into the complex system metabolism occurring at submerged sinkhole ecosystems of Lake Huron. Keywords: Ecosystems, Biogeochemistry, Lake Huron.

BIDLEMAN, T.F. 1, WATSON, S.B. 2, RIDAL, J.J. 3, and STARK, T. 4, 1Centre for Atmospheric Research Experiments, Science and Technology Branch, Environment Canada, 6248 Eighth Line, Egbert, ON, L0L 1N0, Canada; 2Aquatic Ecosystem Management Research, Environment Canada, Canada Centre for Inland Waters, 867 Lakeshore Road, Burlington, ON, L7R 4A6, Canada; 3St. Lawrence River Institute of Environmental Sciences, 2 Belmont St., Cornwall, ON, K6H 4Z1, Canada; 4IQsynthesis, 11810 Borman Dr., St. Louis, MO, 63146, USA. Chiral Taste and Odor Compounds in the St. Lawrence River and Lake Ontario.

Geosmin (trans-dimethyl-trans-9S-decalol) is a principal cause of musty odor and taste in drinking water drawn from the St. Lawrence River and the Great Lakes. Geosmin is a sesquiterpenoid produced by some cyanobacteria, Streptomyces and other actinomycetes (soil bacteria) and fungi such as Penicillium. It is a principal odor component in soil and has been identified in lakes, reservoirs, pulp mill effluent treatment ponds, and wine contaminated by moulds. Reports indicate that the (–) enantiomer is the naturally synthesized form of geosmin, although the enantiomer composition of geosmin found in the Great Lakes has not been characterized. This is important, since the odor threshold of (–) geosmin (<10
ng/L) is about 10 times lower than the (+) form. The commercial standard used by most labs for sensory and chemical analyses is a racemic mix. Extracts of water collected from the St. Lawrence River and Lake Ontario, and from pure cultures of microorganisms, were analyzed for geosmin and a second musty-flavored terpenoid, 2-methylisoborneol (2-MIB). Concentrations ranged from 2.2-8.7 ng/L for geosmin and 1.1-2.5 ng/L for 2-MIB. Separation and identification of geosmin and 2-MIB enantiomers were achieved by GC-MS on chiral-phase columns. Only the (−) enantiomers were found in all water samples. Keywords: Algae, Impaired water use, Lake Ontario.


A study was conducted exploring the potential use of MODIS Aqua wavebands in the red/near-infra-red for estimating concentrations of suspended particulate matter (SPM) in the turbid waters of Lake Erie. At these longer wavelengths the influence of dissolved organic matter and chlorophyll on the optical properties is greatly reduced thereby offering improved accuracy in the determination of SPM concentrations from satellite observations of aquatic color. Daily MODIS aqua imagery were obtained and processed for the retrieval of spectral water-leaving radiance over Lake Erie. A strong correlation was found between water-leaving radiance at 748 nm and coincident in situ measurements of surface SPM concentrations, suggesting it may be possible to use inverse optical modeling techniques to accurately retrieve SPM concentrations at this wavelength. The absorption and scattering properties required as inputs into these models were determined for Lake Erie during research cruises in 2004/05. Results of the modeling procedures are outlined and used to create maps of SPM concentrations for Lake Erie. Keywords: Remote sensing, Lake Erie, Sediment resuspension.

BIRCEANU, O.1, MCCLELLAND, G.B.2, and WILKIE, M.P.1, 1Department of Biology, Wilfrid Laurier University, Waterloo, ON, N2L3C5; 2Department of Biology, McMaster University, Hamilton, ON, L8S4K1. Different Effects of TFM on Gill Function and Toxicity in Larval Sea Lamprey (Petromyzon marinus) Compared to Rainbow Trout (Oncorhynchus mykiss).

The lampricide, 3-trifluoromethyl-4-nitrophenol (TFM), is applied to streams containing larval sea lampreys to control parasitic lamprey populations in the Great Lakes. However, the mode of action of TFM is unclear. One hypothesis is that it inhibits oxidative ATP production by mitochondria, leading to fuel deficits and death. A second hypothesis is that it may cause death by interfering with ion uptake (e.g., Na+) at the gills. We tested this second hypothesis by exposing larval lamprey and rainbow trout to sub-lethal concentrations of TFM for 12 h. Radiotracer experiments using 24Na+ revealed that TFM exposure caused an immediate and sustained 50-60% decrease in Na+ uptake by trout, but not larval lamprey. However, the Na+ uptake disturbance was reversible when the trout were transferred to TFM-free water. Mean cellular haemoglobin concentration (MCHC) increased by 3-4 times after 12 h of TFM exposure in trout, but not in lamprey. This finding suggests that by compromising ion uptake at the trout gill, TFM exposure may have led to osmotic (water) imbalances and blood cell shrinkage. Thus, the mode of TFM toxicity in trout compared to lampreys may be different, but reversible. The authors gratefully
acknowledge the Great Lakes Fishery Commission for funding this project. Keywords: Comparison studies, Fish, Pesticides.

BOBROWSKI, R.J.1, DESJARDINS, M.2, WILSON, C.C.2, and JONES, N.E.2, 1Watershed Ecosystem Graduate Program, Trent University, Peterborough, ON; 2Ontario Ministry on Natural Resources, Peterborough, ON; 3None, None. Survival, Growth, and Emigration of Stocked Atlantic Salmon in Lake Ontario Streams.

Atlantic salmon (Salmo salar) were once abundant in Lake Ontario, but died out in the late 19th century. Key information needs for restoration include determining stocking and recruitment success of different stocked life stages, and assessing life-stage specific survival contributing to adult returns. To address these, we are assessing the relative survival and growth of different life stages (fry, fingerlings, and yearlings) stocked in tributaries, as well as their timing of emigration to Lake Ontario with respect to environmental cues. Results from the first field season indicate substantial differences in survival and timing of out-migration among stocked life stages. Abundance and distribution of stocked fish in lotic habitats were assessed by backpack electrofishing; emigrating smolts were captured using a stationary fyke net in the lower reaches of Cobourg Brook. Numbers of emigrants were estimated using injected tags and stratified mark-recapture techniques; identification of life stages relied on fin clips, scale pattern analysis, and size distribution. Outmigrating smolts from Cobourg Brook (n=7748) showed bimodal emigration intervals: one strong pulse coincided with spring stream discharge and warming temperatures, and a second, more diffused, emigration peak continued until mid- summer. Keywords: Fish populations, Fisheries, Fish management.

BODAMER, B.L. and BOSSENBROEK, J.M., University of Toledo - The Lake Erie Center, 6200 Bayshore Rd., Oregon, OH, 43618. Wetlands as Barriers: Effects of Vegetated Waterways on the Downstream Dispersal of Zebra Mussels (Dreissena polymorpha).

Stream flow is a major vector for zebra mussel spread among inland lakes. I hypothesized that vegetated waterways, i.e., wetlands, would hinder downstream dispersal of zebra mussels in connected inland lake systems. To test this hypothesis, veliger (larva) abundance, recruitment, and adult mussels were surveyed in four lake-wetland systems in southeastern Michigan, USA from May through August 2006. Sampling was conducted downstream of the zebra mussel invaded lakes, beginning at the upstream edge of aquatic vegetation and continuing downstream through the wetland streams. Results showed that veliger abundance decreased rapidly in vegetated waterways compared to their previously reported rates of decrease in non-vegetated streams. Veligers were rarely found more than 1 km downstream from where vegetation began. Newly recruited individuals and adults were extremely rare beyond open water in the study systems. These results suggest that densely vegetated aquatic ecosystems limit the dispersal of zebra mussels downstream from invaded sources. Keywords: Zebra mussels, Dispersal, Dreissena, Veligers, Wetlands, Source-sink dynamics.
BOEGMAN, L.¹, LOEWEN, M.R.², CULVER, D.A.², and HAMBLIN, P.F.⁴, ¹Department of Civil Engineering, Queen's University, Kingston, ON, K7L3N6; ²Department of Civil and Environmental Engineering, University of Alberta, Edmonton, AL, T6G 2W2; ³Department of Evolution, Ecology and Organismal Biology, The Ohio State University, Columbus, OH, 43210; ⁴National Water Research Institute, Environment Canada, Burlington, ON, L7R 4A6.  Coupling Between Stratification, Mixing and Dreissenid Grazing Impacts in Western Lake Erie.

Dreissenid mussels are an invasive species that have been implicated in the reduction of algae stocks in the near-shore environment of western Lake Erie. Here, we numerically model their basin-wide effects during 1994. When modeled as true benthic organisms (resting on the bottom), the dreissenids grazed 53% of the western basin net algal growth resulting in a 0.1 mg/L reduction in the pelagic algae concentration relative to the case without dreissenids. In comparison, dreissenids grazed 77% of the western basin algal growth when the lake was fully mixed. The biomass grazed was governed by a balance between the timescales of vertical wind-induced mixing and benthic grazing. During calm conditions, weak stratification (~ 1°C between surface and bottom waters) was sufficient to suppress vertical mixing. Under these conditions a concentration boundary layer CBL ~ 1 m thick formed wherever the dreissenid areal pumping rate is greater than 2 m⁴m⁻²d⁻¹; thus accounting for the reduced grazing effect relative to the fully mixed case. Entrainment of the CBL occurred when the mean daily wind speed 4 m above the lake surface U > 6 m/s (associated with the characteristic 10-d storm cycle). Typically in western Lake Erie, U < 6 m/s, the water column is weakly stratified and a CBL is present.

Keywords: Dreissena, Hydrodynamics, Lake Erie.

BOLLIN, T.², HAPONSKI, A.E.¹, and STEPIEN, C.A.¹, ¹6200 Bayshore Rd., Oregon, OH, 43618; ²Scott Park Campus, Toledo, OH, 43607.  Genetic Divergence Patterns of the Rainbow Darter Etheostoma caeruleum: A Watershed Analysis using Mitochondrial DNA Sequences and Nuclear Microsatellites.

The rainbow darter Etheostoma caeruleum is a common small benthic fish in the eastern United States, whose population genetic structure in the Great Lakes region is largely unknown. Our study analyzes mitochondrial DNA sequences from the cytochrome b gene (cyt b; 1122 bp) and 8 nuclear microsatellite loci to compare population genetic variation of the rainbow darter from the Lake Erie watershed (Blanchard, Chagrin, Cuyahoga, Grand Rivers) versus the Ohio River watershed (Big Darby Creek and Little Miami River). We identify 34 cyt b haplotypes that are differentially distributed between the two watersheds, and fine-scale relationships within their respective tributaries are further resolved using microsatellites. Bayesian Structure analysis reveals two distinct clusters between the watersheds, which diverge by θST = 0.378 and a pairwise distance of 0.014, dating to ~700,000 years ago according to a cyt b molecular clock calibration for darters. Within the two systems, greater divergence distinguishes the Ohio River locations (θST = 0.094), reflecting less connectivity, than is found among the tributaries linking with Lake Erie. Lake Erie tributary populations also are differentiated using microsatellites, showing fine-scale patterns. Keywords: Biodiversity, Fish populations, Genetics.
BOOTY, W.G.,1 and BOWAN, G.S.,2 1National Water Research Institute, 867 Lakeshore Road, Burlington, ON, L7R4A6; 2Toronto and Region Conservation, 5 Shoreham Dr., Downsview, ON, M3N1S4. The Determination of Stream Loadings and the Identification of Sources of Contaminants along the North Shore of Lake Ontario.

Lake Ontario serves as the drinking water supply for over six million Ontario residents and is the subject of a special study funded by the Ontario Ministry of Environment to protect lake-based drinking water intakes. Also, in 2008, an intensive Canada/U.S. nearshore monitoring program will take place in Lake Ontario. On the Canadian side of the lake there are four focused sampling areas. Because adequate stream flow and water quality data are missing for most of the watersheds, in Phase 1 of the project we employed a range of estimation procedures designed to provide an approximation of the loads. Loadings for nutrients and suspended solids were determined through the use of several different methods: event mean concentrations coupled with runoff volumes for daily, monthly, and annual time steps; unit area loadings on a watershed and sub-watershed basis; directly calculated loads using combined stream and flow chemistry; and non-point source model estimated peak loads for major storm events. In phase 2 enhanced monitoring of the priority tributaries, along with more detailed watershed-based modeling assessments, are being carried out to identify sources and to better quantify the loads. In addition, other drinking water quality parameters are also being investigated to expand our understanding of effective watershed BMPs. Keywords: Monitoring, Lake Ontario, Model studies.

BORTONE, S.A., MOEN, S., SCHEUER, D., and JOSEPH, A., Minnesota Sea Grant College, 2305 East Fifth St., Duluth, MN, 55812. Recent Trends in Great Lakes Research: Information for Those Who Suffer from Lake Envy!.

There is an unspoken, or at least subtle, adage that some lakes “get more than their fair share” of attention when it comes to research funding, initiatives, and effort. We examine this adage by evaluating the research focus in abstracts presented over the past 20 years at the annual IAGLR conferences. All abstracts were read and tabulated for research conducted according to lake (Superior, Michigan, Huron, Erie, and Ontario), subject matter (fish, frogs, chemicals, plankton, sediments, etc.), and year. We also examined the results with regard to bias created when the host institution was proximate to a particular lake. For example, this past year (2007) a preponderance of the presentations were about Lake Erie but the IAGLR conference was held at nearby Penn State University. Adjustments to the analyses incorporated other considerations that included lake specific features such as size (volume, area, and drainage area), associated human population, financial importance, and environmental conditions (e.g., nutrient levels). There have been significant increases in research related to education, aquatic invasive species, hypoxia, and wetlands and declines in research regarding mammals, arthropods, economics, and sediments. A notable conclusion: Sometimes some lakes get more attention than they deserve – sometimes not! Keywords: Great Lakes basin, Public education, Water quality.

BOUGHTON, L.,1, LAPLANTE, E.,2, and SIMON, M.B.,2 1Pennsylvania Department of Environmental Protection, 230 Chestnut St., Meadville, PA, 16335; 2United States Environmental Protection Agency, 77
Illuminating the Great Lakes: LaMPs as the Model for Ecosystem Management.

The Lakewide Management Plan (LaMP) serves as the model for ecosystem management for the Great Lakes basin. Born out of the 1972 Great Lakes Water Quality Agreement, each of the Great Lakes is managed by either a LaMP or an appropriate program. The LaMPs apply the practical methods of an ecosystem approach to regional policy and resource management through stakeholder diversity, ongoing cooperation, and adaptation to changing environmental and political conditions. The LaMPs foster cross-sector collaboration between local, state, and federal stakeholders and exemplify binational partnership between the U.S. and Canada. LaMPs provide structure for coordinating research, pooling resources, making joint commitments, and identifying funding priorities. The LaMP adaptive management approach addresses persistent issues and systematically incorporates emerging issues, such as the effects of global climate change. The successes and failures of the LaMP can also be identified when considered as the ecosystem model. LaMPs should be the guiding framework for the management interventions needed, as the GLWQA defines, to “maintain and restore the physical, chemical, and biological integrity of the waters of the Great Lakes basin ecosystem.” Keywords: Policy making, Public involvement, Management, Ecosystem approach, Water quality, Research.

Relating Species Traits to Habitat Characteristics in Coastal Wetlands of the Lower Great Lakes.

It is well known that habitat characteristics play a critical role in structuring fish assemblages. Generally, relationships are determined between species assemblages and habitat characteristics first and in some cases these relationships are related to certain key traits. However, fourth-corner analysis directly associates species traits to habitat characteristics. We tested these associations in wetland systems of the lower Great Lakes. Fish and habitat surveys were conducted in 12 wetlands. A literature search was completed to gather information on 42 life-history and biogeographical characteristics for 129 fish species. We predicted, a priori, specific species trait and habitat associations based on our literature search. Results indicated that the environmental variables with the greatest significant relationships to the life-history and biogeographical characteristics were the area of the tertiary watershed, macrophyte coverage. Of the 49 predicted associations approximately half were correct (49-53% correct predictions). However, 72-83% of the predicted associations related to vegetative coverage were correctly predicted. This method provides a very important framework which may be incorporated into risk assessments for invasive species, and used to predict effects of climate change on species distributions. Keywords: Coastal wetlands, Fish, Species composition.


BOWEN, K.L.¹, GERLOFSMA, J.¹, and LORENTZ, J.A.², ¹Fisheries and Oceans Canada, 867 Lakeshore Rd., Burlington, ON, L7R 4A6; ²University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1. Abundance and Population Dynamics of *Mysis relicta* in Lake Huron 2007.
The lower food web of Lake Huron has undergone dramatic changes following the spread of quagga mussels (*Dreissena bugensis*) and the spiny water flea *Bythotrephes*. *Diporeia*, zooplankton, phytoplankton, and alewife appear to have declined markedly since 2003. However, the status of the opossum shrimp *Mysis relicta* is largely unknown in Lake Huron, despite its intermediate position in the food web. In 2007, following sampling done in 2003, we sampled the mysid population at four stations seasonally (spring, summer, and fall) and did a lakewide survey in August. Mean abundance was low in May (24 mysids/m²) and increased through August (115/m²) and into October (151/m²). Compared to our 2003 data, May and August densities were low. The maximum abundance of 200/m², found in Oct 2007, was also considerably lower than the 847/m² found in 1971 by Carpenter *et al.* As with the other Great Lakes, abundance increased with depth. August sampling showed lower populations of mysids in Georgian Bay compared to L. Huron. Keywords: Populations, Mysids, Lake Huron.

BOWEN, K.L.¹, GERLOFSMA, J.¹, SCHANER, T.², and KOOPS, M.A.¹, ¹Fisheries and Oceans Canada, 867 Lakeshore Rd., Burlington, ON, L7R 4A6; ²OMNR, Lake Ontario Management Unit, 41 Hatchery Lane, R.R. #4, Picton, ON, K0K 2T0. Monitoring the Spread of the Invasive Crustacean *Hemimysis anomala* in the Great Lakes.

The first North American reports of the bloody red shrimp (*Hemimysis anomala*) were in Muskegon, MI and Oswego, NY in 2006. This Ponto-Caspian mysid has already invaded many areas of Russia, Europe, and the UK. In contrast to the coldwater native shrimp *Mysis relicta*, this species’ adaptation to shallow, warm waters will allow it to invade many habitats currently free of mysids. *Hemimysis* is a voracious omnivore that consumes phytoplankton, zooplankton, and detritus. To determine its spread and potential effects on the aquatic food web, we sampled nearshore areas of all five Great Lakes in 2007 for both *Hemimysis* and zooplankton. As this mysid prefers rocks and other hard substrates, sampling from docks and breakwalls with bottle traps or nighttime vertical net hauls was often effective. In Lake Ontario, nearshore surface tows taken at night also produced *Hemimysis*. To date, this invader was captured in nearshore areas throughout Lakes Michigan, Ontario, and Erie, but was not found in Lakes Superior, Huron, or the Detroit/St. Clair river corridor. Given its widespread distribution, it likely invaded the Great Lakes some time prior to 2006. Keywords: Invasive species, *Hemimysis*, Monitoring.

BOWERMAN, W.W.¹ and FOX, G.A.², ¹Clemson University, Department of Forestry & Natural Resources, Clemson, SC, 29634; ²Canadian Wildlife Service, National Wildlife Research Centre, Ottawa, ON, K1A 0H3. Analysis of Wildlife Indicators to Measure Impaired Reproduction and Deformities.

One of the health indicators related to the Great Lakes Water Quality Agreement is the Beneficial Use Impairment for impaired reproduction or deformities in wildlife. We examined the literature to determine which wildlife species had defensible cause-effect linkage data, indicating injury from environmental contaminants within the Areas of Concern. Criteria included the ability to identify Toxic Reference Values for reproductive impairment and/or deformities in these species. Only nine wildlife species fit these criteria: mink; snapping turtle; herring gull; Caspian, common, and Forster’s terns; bald eagle; black-crowned night-heron; and double-crested cormorant. Chemicals where TRVs could be
determined for these two endpoints included mercury, dieldrin, p,p'-DDE, and PCBs-PCDDs-PCDFs. No single indicator species could be used for both endpoints and all 4 groups of chemicals. When none of the nine wildlife species are present in an Area of Concern, we have developed a bioaccumulation model to indicate potential effects to wildlife based on concentrations of these chemicals in forage fish. This talk will illustrate the utility and limitations for delisting AOCs based on this beneficial use impairment. 

Keywords: Indicators, Bioindicators, Ecosystem health.


The effects of environmental contaminants on the reproduction of bald eagles (Haliaeetus leucocephalus) are well known. Eagles were one of the primary sentinel species that indicated the impacts of legacy compounds in the Great Lakes region. By the mid-1960s, eagles were nearly extirpated from the shorelines and islands of the lakes. Reproductive outcome for nearly all nests in Michigan has been monitored since 1961. Beginning in the 1970s, unhatched eggs were collected from nests and analyzed for concentrations of environmental contaminants. In the mid-1980s, non-lethal collections of blood and feathers from nestlings began and concentrations within these tissues indicated exposure. We report here on the trends in concentrations of legacy compounds within eggs, blood plasma, and feathers of adult and nestling eagles from Michigan, for the period 1986-2007. Concentration of legacy compounds with the exception of Hg have declined. We have also analyzed these tissues for new and emerging chemicals including PFOS, and will present these data also. Their large size, continuous reproductive database, and great distribution across Michigan allows us to use the eagle as one of the primary biosentinel species for monitoring trends and effects of environmental contaminants. Keywords: Bioindicators, Environmental contaminants, Toxic substances.

BOYER, G.L.¹, SATCHWELL, M.F.¹, DAMON, R.², HOTTO, A.M.¹, and YANG, X.¹, ¹State University of New York, College of Environmental Science and Forestry, Syracuse, NY, 13210; ²Le Moyne College, Syracuse, NY, 13224. Analysis of Cyanobacteria Toxins in Lake Champlain; What This Tells Us about Harmful Algal Blooms in Other Large Lake Ecosystems.

Cyanobacterial toxins have been detected in Lake Champlain for the past 8 years. Since 2002, water samples were collected lake-wide and analyzed for nutrients, algal abundance, and the cyanobacterial peptide toxin microcystin. Microcystin concentrations were determined by the activity based protein phosphatase inhibition assay (PPIA). PCR was used to detect cyanobacterial and Microcystis 16S rRNA genes, and the microcystin biosynthetic genes mcyB, mcyD, and mcyA, which indicate potential microcystin production. Cyanobacterial abundance and microcystin concentrations peaked in late summer and showed a distinct north – south gradient. Toxin levels were highest in Missisquoi Bay, the extreme northeast end of the lake, where concentrations routinely reached 5 μg/L in open water and greater than 30 μg/L in surface scums. PCR analysis indicated that both toxic and nontoxic cyanobacteria are common throughout the lake. Presence of the microcystin biosynthetic genes
outside Missisquoi Bay indicates potential for toxic blooms to occur in other areas of the lake. The neurotoxin anatoxin-a occurred at significant concentrations (>1 μg/L) but was ephemeral and represented unique and nonsystematic events. The relationships between toxin distribution and major nutrient and physical forcing factors will also be presented. **Keywords:** Cyanophyta, Microcystis, Lake Champlain.

BRANDT, S.B.¹, COSTANTINI, M.², LUDSIN, S.A.³, MASON, D.M.¹, and VANDERPLOEG, H.A.¹, ¹NOAA Great Lakes Environment Research Lab, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105; ²World Wildlife Fund, Rome, Italy; ³Aquatic Ecology Laboratory, Ohio State University, Columbus, OH, 43212. **Spatially-explicit Growth Predictions to Assess Habitat Quality of Walleye during Hypoxia in Lake Erie.**

Biological and environmental data were used to quantify the effect of hypoxia on habitat quality of walleye in the Lake Erie central basin. Walleye growth rate potential (GRP) was modeled along kilometer-scale transects at 4-hr intervals across the diel cycle. Transects were sampled during August (before hypoxia), September (during hypoxia), and October (after hypoxia), 2005. We introduced a detrimental effect of reduced DO concentrations (3 mg L⁻¹) on walleye consumption in a prey-temperature GRP model to estimate growth within the species optimal foraging light range. Results showed that walleye habitat quality (GRP>0) was only slightly reduced by bottom hypoxia per se. Maps showed also that GRP followed the distribution of preyfish, which, in turn, aggregated in oxygenated waters. Accordingly, hypoxia did not largely affect the walleye habitat quality per se. In contrast, by concentrating prey in oxygenated waters and forcing them up in the water column, hypoxia might have the potential to increase prey density at depths where light levels and temperatures are optimal to forage. Results should be useful in evaluating how increasing hypoxia in Lake Erie might affect overall walleye production. **Keywords:** Lake Erie, Walleye, Oxygen.

BRIDGEMAN, T.B. and SIGLER, W.V., Dept. of Environmental Sciences and Lake Erie Center, University of Toledo, Toledo, OH, 43606-3390. **Lyngbya wollei Blooms in Western Lake Erie 2006-2007.**

We report observations on the first known major bloom of the potentially toxic filamentous cyanobacteria, *Lyngbya wollei*, in Lake Erie. In early September 2006, a period of strong northeast winds and accompanying elevated water levels and wave action deposited large mats of *L. wollei* in coves along the southern shore of Maumee Bay. These mats remained intact over the winter and new growth was observed along the margins of the mats in April 2007. Mats ranged between 0.2-1.2 m in thickness and we estimated that one 100 m stretch of shoreline was covered with approximately 200 metric tons of *L. wollei* (wet weight). Near-shore benthic mats growing at water depths of 1.5 m were observed in August 2007. Patterns of *L. wollei* growth and mobility appear similar to reports from other regions as large portions of the mats became detached from the bottom in September 2007 and were observed floating up to 10 km offshore. Fresh shoreline material was analyzed in spring of 2007 using ELISA to detect paralytic shellfish toxins known to occur in *L. wollei*. Saxitoxins (saxitoxin plus analogues) were detected at a concentration of 1.1 g saxitoxin g⁻¹ dry weight (+/- 0.02). **Keywords:** Harmful algal blooms, Lake Erie, Invasive species.

As part of a broader assessment of wildlife health in Great Lakes Areas of Concern (AOCs) we are examining wild-fish for evidence of exposure to thyroid disruptors. Thyroid microfollicular hyperplasia was a continuing problem in Great Lakes salmonids as recently as 1995. We will focus on the “Lake Erie AOCs”: Wheatley Harbour, the St. Clair River, and the Detroit River. We divided each AOC into upstream, impact zone, and downstream sites. At each site, we captured adult males and females of a pelagic and a benthic species. We assessed the external and internal state of the fish by visual estimation of malformations such as lesions, tumors, parasites, and eroded fins (DELTs). We used a suite of assays to detect perturbations in the thyroid axis. Those assays can detect changes in the production of T4 (thyroxine) and in the peripheral production of T3 (tri-iodothyroxine) from T4. T4 and T3 de-iodinase activity were measured in liver microsomal fractions. We measured thyroid epithelial cell height and assessed follicular condition in slices through that gland. The results, which showed some evidence of hormonal perturbation, shall be discussed within the context of the thyroid system’s ability to compensate for stress on one or other of its component parts. *Keywords: Ecosystem health, Fish, Bioindicators.*


To the limited extent practicable, through the IJC, levels of Superior and Ontario have been regulated to maximize economic, social, and environmental benefits, especially when levels are high or low in the historical range. What should be done when those high and low events become more frequent and extreme, especially since levels are high or low in the historical range? This is the essence of the International Upper Great Lakes Study (IUGLS). Levels of Lakes Superior and Michigan-Huron have been near or below record lows since autumn 2007. Possible reasons for the decline in levels must be assessed in order to recommend suitable action. Among these, in addition to a “drainhole” or continuing erosion in the St. Clair River as some have proposed, are glacial isostatic rebound, diversions of water out of the system, changes in precipitation, evaporation, and runoff. If the causes are hydroclimatic, are they due to natural variability which will soon return to “normal,” or a manifestation of longer term climate change? This 5 year study will address the St. Clair River issue first, with a report due in 2009, and later consider modifications to Lake Superior regulation. The Study approach and scientific results from the first year’s work will be presented. *Keywords: Water level, IUGLS, St. Clair River, IJC, Lake Superior.*

Zebra mussels (*Dreissena polymorpha*) are very effective ecosystem engineers, impacting both the physical and biological environment. They change the existing and provide a new habitat for native bottom organisms, and affect trophic interactions and the availability of food for both benthic and pelagic species. To compare the effect of zebra mussels on native invertebrates we studied density and composition of zoobenthos within *D. polymorpha* aggregations (druses) formed on different sediment types, and in the bare sediments near druses, in glacial lakes in North America and Europe. Benthic community associated with *Dreissena* in both North American and European lakes had higher density, biomass, and species richness. Regardless of the type of sediment where *Dreissena* druses were formed, benthic community within druses (excluding zebra mussel) was always remarkably similar and dominated by amphipods, leaches, midges, and mayflies. In contrast, zoobenthos density and dominant species in bare sediments differed significantly depending on the substrate type. By forming druses on various substrates, zebra mussels create new multi-dimensional habitat colonized by invertebrates that are generally uncommon in fine sediments, increasing the local biodiversity and heterogeneity of benthic communities. **Keywords:** Benthos, Zebra mussels, Species composition.


Compound degradation versus sample holding time was investigated for four herbicides; atrazine, glyphosate, 2,4-D (2,4-dichlorophenoxyacetic acid) and metolachlor using a magnetic-based, competitive direct, enzyme-linked immunosorbent assay (ELISA). The concentration of each pesticide in several surface water matrices from southern Ontario was determined and monitored for two identical sample batches, frozen and unfrozen. Subsamples were analyzed over the span of eight weeks in order to develop a stability value for each pesticide. Regression analysis showed that both frozen and unfrozen samples demonstrated a relatively insignificant difference in stability value for atrazine and metolachlor. The reliability of ELISA results for surface water samples was evaluated against gas chromatography/mass spectrometry (GC/MS) for 2,4-D, atrazine, and metolachlor and liquid chromatography/mass spectrometry (LC/MS) for glyphosate. Comparative analysis between wet chemistry methods and ELISA revealed a R2 value of 0.35, 0.92, 0.32, and 0.88, for the above mentioned herbicides, respectively. The commercially available 2,4-D and metolachlor ELISA kits appeared to be unreliable alternatives to GC/MS analysis while glyphosate and atrazine ELISA test kits were determined to compare quantitatively with traditional analysis. **Keywords:** Pesticides, Atrazine, Glyphosate.

BYER, J.¹, STRUGER, J.¹, KLAWUNN, P.¹, SVERKO, E.¹, and TODD, A.², ¹Environment Canada, Box 5050, Burlington, ON, L7R 4A6; ²Ontario Ministry of the Environment, Toronto, ON. **Large Scale Field Utilization of the ELISA Method as a Water Quality Monitoring Tool for Surface Water Samples in Ontario.**

A total of 739 surface water samples from over 100 sampling locations throughout Ontario were monitored using enzyme-linked immunosorbent assay from April to October 2007, in order to obtain spatial and temporal trend information. Concentrations exceeded the method detection limit in 38% and
26% of the samples for atrazine and glyphosate, respectively. The highest concentrations for both pesticides were observed in samples collected during a precipitation event. Atrazine concentrations exceeded the Canadian Water Quality Guideline for the protection of freshwater aquatic life (1.8 µg/L) in less than 1% of the samples (6 of 739 samples). The highest concentrations of atrazine were observed in late spring/early summer in agricultural watersheds. Glyphosate concentrations showed a bimodal distribution with peak concentrations occurring in late spring/early summer and autumn. Glyphosate concentrations did not exceed the guideline for the protection of aquatic life (65 µg/L) in any of the samples. The highest concentration of glyphosate was 12.02 µg/L associated with a precipitation event in an urban watershed. Keywords: Pesticides, Watersheds, Atrazine, Glyphosate.

CAMPBELL, G.D.¹, WELCH, M.K.¹, BARKER, I.K.¹, MOCCIA, R.D.², and ROBINSON, J.T.³, ¹Ontario/Nunavut Region, Canadian Cooperative Wildlife Health Centre, Dept. of Pathobiology, Ontario Veterinary College, University of Guelph, Guelph, ON, N1G 2W1; ²Aquaculture Centre, Dept. of Animal & Poultry Science, Ontario Agricultural College, University of Guelph, Guelph, ON, N1G 2W1; ³Canadian Wildlife Service, 465 Gideon Dr., London, ON, N6P 1Z7. Canadian Experience - Type E Botulism in Fish-eating Birds on the Lower Great Lakes: A Consequence of Invading Alien Species?

Clostridium botulinum Type E spores are widely distributed in aquatic ecosystems, but until recently, Type E intoxication has rarely been associated with large-scale wildlife mortality. Since 1998, Type E botulism involving thousands of shorebirds, gulls, terns, diving ducks, mergansers, grebes, cormorants, and loons has occurred in southern Lake Huron, progressing down Lake Erie into Lake Ontario in 2002. Unusual in terms of the number of avian species involved, their geographic scope, their size, and their recurrent nature, these outbreaks may reflect fundamental ecological shifts in the lower Great Lakes associated with invading alien species. Predisposing factors may include perturbations associated with eruptions of invasive dreissenid mussels, and round gobies. Type E botulism toxin may be evolved in a suitable redox environment in the extensive mussel beds on the lake bottom, and may be concentrated in mussels. Fish such as gobies may acquire toxin through feeding in mussel beds and act as a source of toxin for predatory fish or for fish-eating birds higher in the food web. Mussel-feeding diving ducks may acquire toxin directly, rather than via a fish “vector.” Scavengers such as gulls may acquire toxin through consumption of toxin-containing carcasses, and shorebirds through consumption of toxic invertebrates. Keywords: Botulism Type D, Avian diseases, Invasive species.

CAMPBELL, L.M.¹, MUIR, D.C.G.³, POULOPOULOS, J.¹, BACKUS, S.³, KYSER, K.¹, COX, L.¹, ARRIBÈRE, M.⁴, and HECKY, R.E.², ¹School of Environmental Studies, Queen's University, Kingston, ON, K7L 3N6; ²Large Lakes Observatory, University of Minnesota, 2205 E. 5th St., Duluth, Minnesota, MN, 55812-2401; ³Environment Canada, 867 Lakeshore Road, Burlington, Ontario, ON, L7R 4A6; ⁴Centro Atómico Bariloche, Avenida E. Bustillo 9500, 8400 Bariloche, Argentina. Food Web Contaminant Trends in Great and Large Lakes of the World.

Biomagnification of mercury and metals is a concern world-wide. We review our food web data collected from great and very-large lakes of the world spanning three continents (North America, Africa,
and South America), collected in conjunction with many collaborators. The Great Lakes include lakes from the only two Great Lakes systems in the world, the Laurentian and the African Great Lakes. The very large lakes include Lake Champlain in USA, Lake Albert in Uganda, and Lake Nahuel Huapi in Argentina. We discuss spatial and temporal trends for mercury and key metals. Food web bioaccumulation trends are compared and contrasted across lakes and continents. Keywords: Mercury, Metals, Food chains.


Wheatley Harbour, a small commercial fishing harbor on the north shore of Lake Erie, was designated an Area of Concern (AOC) in the 1970s because of dissolved oxygen depletion, elevated bacterial levels, nutrient enrichment, and PCB contamination of sediments. The AOC encompasses the harbor proper and the wetlands in lower Muddy Creek, a small tributary which flows into the AOC from the north. The development of the Wheatley Harbour Remedial Action Plan (RAP) was initiated in 1986, and a combined Stage 1/Stage 2 report was completed in 1998. The report highlighted five environmental concerns resulting in the impairment of the following beneficial uses: (1) restriction on fish and wildlife consumption, (2) restriction on dredging activities, (3) eutrophication or undesirable algae, (4) loss of fish and wildlife habitat, and (5) degradation of fish and wildlife populations. Numerous activities have been undertaken by the RAP toward understanding and restoring these impairments. Actions have been guided by delisting criteria and water use goals developed in consultation with the local community. This presentation provides an overview of the efforts made by the RAP partners toward delisting the Wheatley Harbour AOC. Keywords: Great Lakes basin, Impaired water use, Remediation.


The residents of Akwesasne have been exposed to polychlorinated biphenyls (PCBs) through consumption of contaminated fish and by breathing contaminated air. My colleagues and I have studied routes of exposure through analysis of PCB congener patterns in various media and human blood, and have explored the relationship between exposure and various diseases. PCBs levels in this population are only slightly higher than those in the general population. Young people have a PCB pattern that corresponds to that in air, indicating that inhalation as well as ingestion is an important route of exposure. We have demonstrated a significant relationship between elevations of total serum PCB levels in adult Mohawks and diagnosis of diabetes (OR = 3.9 comparing highest to lowest tertile of exposure), elevations in total serum lipids leading to increased cardiovascular disease and reduction in serum testosterone levels in both men and women. In addition we find that higher levels of PCBs are associated with reductions in thyroid hormone function in both adolescents and adults. Serum levels of DDE and hexachlorobenzene were also positively correlated with some of these diseases, although that of mirex was not. We conclude that even modest exposure to PCBs is associated with elevations in rates of several diseases. Keywords: Environmental health, PCBs, St. Lawrence River.
CARRICK, H.J. and LASHAWAY, A.R., School of Forest Resources, Penn State University, University Park, PA, 16802, USA. **Remnants of the Spring Diatom Bloom May Regulate Hypoxia in Lake Erie.**

Sedimentation of phytoplankton cells following surface blooms is commonplace, and these events have been tied to hypoxia in some large lake and coastal ecosystems. Our previous work in Lake Erie shows that planktonic diatom species dominate the benthic assemblage in the central basin, and chlorophyll concentrations in the benthos decline significant throughout the thermally stratified period (June-September). We tested that hypothesis that oxidation of algal chlorophyll on the bottom of the lake accounts for the lions-share of oxygen loss in the hypolimnion in lake Erie. During on 18 basin-wide cruises, seasonal sampling of the benthos (May-October) was done over four years (2002, 2003, 2005, and 2007). Undisturbed benthic samples were retrieved on using a box corer so that surficial sediments could be removed and analyzed for chlorophyll, phaeopigments, and algal cell counts. In all years, chlorophyll concentrations decreased with time after thermal stratification (range 1,000 to 100 mg/m²). In 2007, the rate of decline at two stations suggests that the oxidation of algal material can account for a majority of oxygen drawdown from the central basin (algal carbon loss of -20.6 mg/m²/days). These appear to be representative of basin-wide patterns, as measured among 18 stations throughout the central basin in 2002. **Keywords: Diatoms.**


During a hypoxic period in the central basin of Lake Erie zooplankton were collected from sites that varied in levels of dissolved oxygen (O₂) concentrations from <1 to 4 mg/L in the hypolimnion. To observe the effects of low O₂ concentrations on vertical migration patterns of zooplankton, samples were collected with a pump from the epilimnion, metalimnion, and hypolimnion. Under normoxic conditions many zooplankton species migrate to deep regions of the water column during the day to avoid predation from visually feeding fishes and invertebrate predators like *Bythotrephes longimanus*. During moderately hypoxic conditions (2 mg/L O₂) cyclopoids, *Bosmina*, and some *Daphnia mendotae* were found in the hypolimnetic zone with total zooplankton densities of 80,000 and 100,000 per m⁻³, day and night respectively. During severe hypoxic conditions (<0.7 mg/L O₂), few were found in the hypolimnion, with total zooplankton densities of 482 and 630 per m⁻³, day and night respectively. *Bythotrophes*, a preferred prey of fishes, was more abundant at sites with low O₂ concentrations. This may be a result of the fishes moving out of such regions and more overlap of *Bythotrophes* with its prey that was denied its hypolimnetic refuge. **Keywords: Zooplankton, Lake Erie, Oxygen.**

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U.S. Highway 2, Ironwood, MI, 49938, USA.  **Intervention Strategies for Limiting the Spread of Aquatic Invasive Species by Recreational Boaters.**

Small-craft recreational boating is an important secondary vector for the spread of aquatic invasive species (AIS) within and beyond the Laurentian Great Lakes basin. We surveyed recreational boater movement patterns and AIS hygiene behaviors in northern Wisconsin and the Michigan UP. Almost 70% of boaters showed high fidelity to single lakes, and thus pose a low risk of spreading invaders. Of the boaters visiting multiple lakes 90% travelled < 15 km between water bodies. Despite recreational fishers accounting for 90% of boaters, the small number of fishing guides surveyed collectively visited the largest number of lakes. Boaters showed good awareness of the risks they pose for the spread of aquatic weeds, but only 46% pressure wash their boats and 90% did not drain live wells between lakes. However, most (87%) boaters reported a willingness to use boat-washing facilities if available. We have used these data to assess the risks of AIS spread posed by different boater groups (e.g., guides, visitors, permanent residents), to identify the most important local sources of invasive species, and to determine those lakes most at risk of new introductions. Results will enable targeted education programs, and guide the type and location of intervention measures to reduce the risk of AIS being transported on recreational boats.

**Keywords:** Invasive species.

CHAFFIN, J.D.¹, BRIDGEMAN, T.B.¹, and FILBRUN, J.E.², ¹Department of Environmental Science & Lake Erie Center, University of Toledo, Oregon, OH, 43618; ²Department of Biological Sciences, Bowling Green State University, Bowling Green, OH, 43403.  **Quantification of Microcystis sp. Blooms in Western Lake Erie (2002-2007) and Relation to Tributary Flow.**

The magnitude of *Microcystis* blooms in western Lake Erie varies considerably between years and is potentially related to environmental conditions. However, quantifying blooms using cell counts and satellite data presents challenges and limitations. We investigated an alternative approach using a density technique to separate *Microcystis* from other algae in preserved western Lake Erie plankton samples (N=343) and to obtain robust estimates of bloom magnitude for summers of 2002-2007. Traditional cell counts (N=60) demonstrated the efficacy of the density separation method (counts vs. volume; $r^2=0.842$). *Microcystis* volume in the water column varied considerably between years, with maximum peak volumes (892.3 mL m⁻²) in September 2003, and minimum peak volumes (67.3 mL m⁻²) in September 2002. Maumee River flow is likely to be a large influence on cyanobacterial blooms in western Lake Erie. For 2002-2006, total summer *Microcystis* volume increased linearly ($r^2=0.931$) with total Maumee River flow (June 1 - August 31). *Microcystis* volume also increased with loadings of total phosphorus ($r^2=0.922$), soluble reactive phosphorus ($r^2=0.917$), and suspended solids ($r^2=0.846$). **Keywords:** Microcystis, Eutrophication, Lake Erie.

CHAPMAN, D.C., USGS-Columbia Environmental Research Center, 4200 New Haven Road, Columbia, MO, 65201.  **Effects of Bighead and Silver Carp on Invaded Environments.**

There exists a substantial body of information on the effects of bighead and silver carps on the limnology and ecology of systems where they have been introduced worldwide, including some emerging
research on environments in North America where the fish have invaded. Risk assessments have established that bighead and silver carps are likely capable of surviving and establishing reproducing populations within the Great Lakes basin. Predictions of effects in the Great Lakes are difficult and at this time would require a high degree of speculation. However, certain mechanisms by which bighead and silver carps change their environment are somewhat consistent across a variety of habitats. Observed effects include changes in zooplankton and phytoplankton communities, including trophic cascade effects, changes in toxic blue-green algae abundance and in toxin production, and in some cases, documented declines in the populations or fitness of native fishes. This presentation will describe these observed effects and discuss the mechanisms of these effects. Keywords: Carp, Risk assessment, Cyanophyta, Zooplankton, Invasive species, Phytoplankton.

CHAPRA, S.C.¹, DOVE, A.E.², and ROCKWELL, D.C.³, ¹Professor and Berger Chair, Tufts University, Medford, MA, 2155; ²Water Quality Monitoring and Surveillance Ontario, Environment Canada, Burlington, ON, L7R 4A6; ³Great Lakes National Program Office, 77 W. Jackson Blvd., Chicago, IL, 60604. Long-term Trends of Great Lakes Chloride.

Data collected over the past 150 years are compiled and analyzed to identify chloride trends in the Laurentian Great Lakes. The data indicate that chloride levels in all the lakes, with the exception of Lake Superior, began rising in the early twentieth century. Lake Michigan’s concentration has continued to increase steadily and currently stands at its maximum recorded level. In contrast, Lakes Huron, Erie, and Ontario reached peak levels in about 1970. Concentrations in these lakes then began to decline due primarily to the reduction of industrial salt discharges. However, recent data indicate that all three systems are now increasing again. The increases in Lake Huron are primarily due to inflow from Lake Michigan. After exhibiting major decreases in the 1970s and early 1980s (due primarily to reductions of industrial sources in the Detroit River and the Cleveland area), chloride levels in Lake Erie are now rising again at a significant clip. This increase in turn is being passed along to induce a comparable increase in Lake Ontario. Keywords: Great Lakes basin, Model studies, Dissolved solids.

CHATTERJEE, A.¹, DEMARCHI, C.², and MICHALAK, A.M.¹, ¹Dept. of Civil and Environmental Engineering, University of Michigan, Ann Arbor, MI, 48109; ²School of Natural Resources and Environment, University of Michigan, Ann Arbor, MI, 48109; ³Dept. of Atmospheric, Oceanic and Space Sciences, University of Michigan, Ann Arbor, MI, 48109. Improving Estimation of Over-lake Precipitation – An Application to Lake Erie.

Over-lake precipitation is a key component of Great Lakes water balance. Yet, reliable estimates of such a component are difficult to obtain in the Great Lakes region due to the lack of gages in the lake themselves and their sparsity in parts of the draining basin. Traditionally, over-lake precipitation is estimated by distance-weighted and other data-driven methods. In spite of their wide acceptance, such methods suffer from intrinsic limitations as they fail to take into account the spatial and temporal variability of rainfall. Potentially, multisensor products combining Doppler radar and rain gage data (MPE) could better estimate over-lake precipitation. However, the presence of biases in MPE products has raised serious concerns on their applicability. In the present study we propose a geostatistical
methodology to spatially integrate these two datasets. Using available gage and MPE data for the Lake Erie region, we developed a suite of spatial interpolation techniques based on universal kriging for estimating monthly over-lake precipitation. Results indicate that this universal kriging setup outperforms gage-only methods and the MPE data during the spring-summer months of 1997-2005 by providing estimates with significantly lower root mean square error and bias. Keywords: Over-lake precipitation, Multi-sensor precipitation estimates, Universal krigging.

CHIANDET, A.S. and XENOPOULOS, M.A., Trent University, WEG Program, 1600 West Bank Dr., Peterborough, ON, K9J7B8. Determinants of Water Quality and Plankton Communities in Urban Stormwater Ponds of the Laurentian Great Lakes Basin.

Stormwater management ponds (SWMPs) are designed to retain urban runoff, with the aim to reduce pollutant load to receiving waters. However, contaminants accumulate in ponds in concentrations greater than surrounding waters, the effects of which are unknown. We sampled 60 SWMPs to: (1) characterize plankton communities, (2) determine whether nutrient levels affect plankton community structure, and (3) determine the role of pond characteristics, management protocols, and landscape characteristics in structuring plankton communities. SWMPs vary widely and are unique compared to surrounding waterways. SWMPs tend to have high total phosphorus and total suspended solids (24-563 μg/L and 0-97 mg/L respectively), extremely high bottom conductivity and surface temperature (207-4,505 μS/cm and 16-32°C respectively) and low oxygen levels (as low as 0.09 mg/L), especially in thermally stratified ponds, which was true of 78% of ponds sampled. Pond age and the presence of forebays were important determinants of water quality. This research will provide water managers with science-based guidelines to use in designing stormwater management systems that remove nutrients more efficiently, in addition to improving understanding of aquatic ecosystems in urban landscapes. Keywords: Stormwater management ponds, Urban watersheds, Phytoplankton, Zooplankton, Water quality, Nutrients.


With the expanse of scientific research being done related to water and water management, there continue to be gaps in the research with respect to First Nations input. As legislation pertaining to water is being proposed, and strategies are being implemented, First Nations are voicing concern about not only the lack of input in these initiatives, but also the virtual absence of any cultural reference therein. The speaker will discuss the importance of including First Nations perspectives and research in science based initiatives related to water. She will reveal how to engage First Nations in research and policy projects. Protocols related to obtaining such input, which vary from First Nation community to community, will be explained. Keywords: Engagement, Water policy, First Nations.

CHOC, S.J., DWYER, D.F., and DESAINT VICTOR, C., University of Toledo, Lake Erie Center, 2600 Bayshore Rd., Oregon, OH, 43618. Escherichia coli and Sediment Load Monitoring in Berger Ditch
with Implications for Reduction of Water Quality Advisories at Maumee Bay State Park, Oregon, Ohio.

Berger Ditch (BD) opens into Lake Erie at Maumee Bay State Park (MBSP) in Oregon, Ohio and is the primary source of fecal contamination for the public swimming beach. Water quality advisories are issued by the Ohio Department of Health when densities of *Escherichia coli* exceed 235 cfu/100 mL. Water within BD was monitored to attain data necessary in formulating a model wetland to improve water quality. Water samples were obtained with an automatic sampler and analyzed for *E. coli* densities, turbidity, and total suspended solids (tss). Discharge was determined using an acoustic doppler velocity meter. From May through December 2007, densities of *E. coli* varied from 834 to 77,000 cfu/100 mL (n=334) and correlated with discharge, turbidity, and tss (R values of 0.62, 0.60, 0.48, respectively). The data were used to design a wetland described herein for reducing microbial and sediment loading to Lake Erie. *Keywords: Environmental health, Escherichia Coli, Gages, Monitoring, Lake Erie, Wetlands.*

CIBOROWSKI, J.J.H.¹ and SHERMAN, K.R.², ¹Dept. of Biological Sciences, University of Windsor, Windsor, ON, N9B 3P4; ²Severn Sound Environmental Assoc., P.O. Box 100, Midland, Midland, ON, L4R 4K6. **Benthic Invertebrate Community Composition in Severn Sound, (Georgian Bay) Lake Huron – 2007.**

Severn Sound was designated an Area of Concern largely because nutrient enrichment caused poor water quality and degraded ecosystem health (including zoobenthos). Benthic community composition indicated that waters of Severn Sound were in a state of recovery following remediation measures that improved water quality in the 1990s. To determine whether these changes have persisted Ponar grab samples were collected at 25 locations (corresponding to areas previously sampled in 1994 and 1998) in Midland Bay, Penetang Bay, and adjacent open waters in April and August 2007. In 1998, 94±34 *Hexagenia* larvae/m² were found at 68% of sites sampled. Cluster analysis identified 3 distinctive groups of sites based on relative community composition. Shallow water (<4 m deep) sites near shorelines were dominated by crustaceans (*Asellus* and *Gammarus*) and *Dicrotendipes* chironomids. A second group of sites characterized by sphaeriid molluscs, Tanytarsini chironomids, 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, densities of many taxa, including *Hexagenia,* were considerably lower than in 1998, although community composition was similar. *Keywords: Lake Huron, Bioindicators, Zoobenthos.*

CLEVINGER, C.C., BADE, D.L., and HEATH, R.T., Kent State University, Department of Biological Sciences, Kent, OH, 44242. **Causes of Hypoxia in Lake Erie: Potential Role of Nitrification.**

The traditional viewpoint of hypoxia in freshwater systems is that excessive phosphorus loadings lead to eutrophication and subsequent respiratory oxygen consumption. Recently this view has been challenged by the reappearance of Central Basin hypoxia even with stable or reduced phosphorus loadings. Measurements of P-uptake, P-debt, and APA activity in the study system indicated limited P-limitation, especially within Sandusky Bay. Other researchers have implicated nitrogen or iron as possible
limiting (or co-limiting) nutrients. These results lead us to investigate another source of oxygen consumption: nitrification. Nitrification can consume large amounts of oxygen, 2 moles of oxygen per mole of ammonia oxidized. Nitrification assays showed significant oxygen consumption attributable to nitrification. This is of special concern, considering the recent increases in nitrogen loadings to the lake. Keywords: Biogeochemistry, Oxygen, Phosphorus.


Canada and the United States have a long history of jointly managing and protecting the Laurentian Great Lakes. Over time, the two countries have broadened their focus from studying and managing these water resources atomistically to adopting an “ecosystem approach” that considers these waters within larger context of the natural and human ecosystems in which they occur. However, this approach is manifested in science and policy across a broad philosophical and practical range in the two nations. Using literature and interview data, we describe some underlying conceptual differences in the approaches adopted in the Great Lakes region and how they ultimately lead to differences in the resulting science and management practices, with the goal of informing future environmental policy and practices in both nations. Specifically, we characterize the key conceptual foundations of the ecosystem approaches adopted, demonstrate the ways in which these foundations influence the “issue space” of each case (e.g., key questions, problem definition), and trace how these foundations are translated into the practice of science, policy, and stakeholder engagement. Keywords: Ecosystem approach, Decision making, Lake management.

COHEN, A.N.,1 and MOLL, R.A.,2 1San Francisco Estuary Institute, 7770 Pardee Lane, Oakland, CA, 94621-1424; 2California Sea Grant, 9500 Gilman Dr., Dept. 0232, La Jolla, CA, 92093-0232. Quagga Mussel Invasion West of the 100th Meridian.

Quagga mussels were discovered in Lake Mead, Nevada in 2007, marking the first establishment of a dreissenid mussel west of the 100th meridian. Lake Mead is a deep reservoir behind the Hoover Dam in the Colorado River basin. Similar to their distribution in the Great Lakes, quagga mussels were found on a variety of substrates and at depths of over 100 m in Lake Mead. Following the flow of the Colorado River, the mussels were subsequently found downstream of the Hoover Dam in Lakes Mohave and Havasu and in the southern California water distribution system. Quagga mussels have now made their way into additional reservoirs, reaching from San Diego, California to Phoenix, Arizona. In response to the threat posed by the quagga invasion, the California Department of Fish and Game created a Science Advisory Panel that developed a series of recommendations on how to cope with the westward expansion of this invasive organism. This presentation will cover the salient points of the quagga invasion west of the 100th meridian, the recommendations of the Science Advisory Panel, and the steps that have been taken to date to address the invasion. Keywords: Invasive species, Exotic species, Dreissena.
COLLINGSWORTH, P.D. and MARSCHALL, E.A., 1314 Kinnear Road, Columbus, OH, 43212.  
**Yellow Perch Spawning Behavior in the Western Basin of Lake Erie.**

The reproductive behavior of yellow perch has been intensively studied throughout its range, but little work has been done in large systems, such as Lake Erie. To determine broad-scale spawning patterns of yellow perch in Lake Erie we sampled spawning aggregations along the southern shoreline of the western basin weekly during spring 2006 and 2007. We then compared models describing spatial patterns in the presence/absence and CPUE of adult yellow perch. For both years, the likelihood of catching yellow perch and the CPUE of these fish increased throughout the spring. Empty trawls were less frequent and CPUE was higher in 2006 than in 2007. More yellow perch were caught in the eastern portion of the western basin than in the western portion in 2006. Finally, the proportion of gravid females captured in our trawls was very high until bottom temperatures reached 11°C, and we began to see flowing and spent females as bottom temperatures rose. Our sampling detected large aggregations of yellow perch in the eastern portion of the western basin and spawning within a narrow range of temperatures. These results document spatial and temporal variability in yellow perch reproductive effort that can be used to develop management strategies that protect spawning aggregations in productive areas and during peak spawning times. **Keywords:** Yellow perch, Lake Erie, Spatial distribution.

COOPER, M.J.¹, UZARSKI, D.G.², BURTON, T.M.³, and BOSCH, A.T.¹, ¹Grand Valley State University, Anis Water Resources Institute, 740 West Shoreline Dr., Muskegon, MI, 49441; ²Central Michigan University, Brooks 156, Mount Pleasant, MI, 48859; ³Michigan State University, 25B Natural Science, East Lansing, MI, 48824. **Invertebrate Biomass and Community Composition in the Muskegon River Drowned River Mouth Wetland: Variability Throughout the Growing Season.**

The Muskegon River widens to form a broad drowned river mouth wetland upstream of its confluence with Muskegon Lake and Lake Michigan. Within the wetland invertebrates form vital linkages between primary producers and higher trophic levels (e.g., birds and fish). We evaluated the importance of season, vegetation type, and microhabitat (sediment, water column, and macrophyte stems) in predicting patterns of invertebrate density, biomass, and community composition. Invertebrate densities increased from 8,958±1,689 m⁻² in May to 43,383±3,161 m⁻² in June to 85,937±13,416 m⁻² in August, 2004. Invertebrate biomass, however, did not increase throughout the growing season (May: 2,273±441 mg m⁻², June: 4,477±1051 mg m⁻², August: 4,061±692 mg m⁻²). Biomass was significantly higher in the sediment and on macrophyte stems than in the water column in May and June but not in August. Nonmetric multi-dimensional scaling revealed a gradient in community composition best explained by season. Our results suggest that while a constant supply of invertebrate biomass is available to higher trophic levels throughout the growing season, the shift in community composition may require higher trophic organisms to adjust behaviors for utilizing this resource. **Keywords:** Coastal wetlands, Macroinvertebrates, Species composition.

CORKUM, L.D.¹, DOPAZO, S.N.¹, and MANDRAK, N.E.², ¹Dept. Biological Sciences, University of Windsor, Windsor, ON, N9B 3P4; ²Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries
We investigated which fish species and environmental factors were associated with two invasive species, round goby and tubenose goby, in nearshore Canadian waters of the Huron-Erie corridor. Thirty sites were sampled in the day and a subset (n=14) at night. We used triplicate beach seine samples to collect fishes. Of 1955 individuals caught in daytime samples, the most abundant fishes were round goby (21.0 %), spottail shiner (17.3 %), and emerald shiner (14.2 %); tubenose goby represented 0.9 % of all fish in the day. Of 1,521 individuals collected at night, the most abundant species were round goby (42.3 %), emerald shiner (24.1 %), brook silverside (9.0 %), and spottail shiner (8.5 %); tubenose goby represented 1.6 % of all fish at night. Characteristic fish assemblages associated with clustered sites were the benthivore (round goby) and two groups of schooling, pelagic fishes (1. emerald shiner and spottail shiner; and, 2. white perch, alewife, gizzard shad, and brook silverside). Tubenose goby, rock bass, and yellow perch were associated with round goby, but did not characterize the group. Results of multiple regression analysis indicated that round goby were abundant in deeper, cooler, clear water. No factors were associated with the tubenose goby. Keywords: Invasive species, Round goby, Fish.

CROLEY, T.E.1, DEMARCHI, C.2, HE, C.3, and HUNTER, T.S.1, 1NOAA Great Lakes Environmental Research Laboratory, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105-1593; 2School of Natural Resources and Environment, University of Michigan, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105-1593; 3Department of Geography, Western Michigan University, 3234 Wood Hall, Kalamazoo, MI, 49008-5424. Performances of the Distributed Large Basin Runoff Model for Different Watersheds in the Great Lake Basin.

The Distributed Large Basin Runoff Model (DLBRM) is a physically based, spatially distributed, hydrology model that is widely used for hydrological forecasting and climate change assessment throughout the Great Lakes region. It is also a major component of the watershed characterization of the ECOFORE 2006 project. The DLBRM was automatically calibrated to reproduce the 1950-1964 and the 1999-2006 flows in 18 watersheds throughout the Great Lakes region. This presentation will analyze how calibration sets and model performances varied in space and time and examine what these tells us about the model robustness, changes in the watershed, and possible effects of climate change. Keywords: Watershed hydrology, Nutrients load, Model validation.


Pharmaceutical and personal care products have been found in diverse aquatic environments. Human antibiotics typically enter groundwater via septic systems. This is a potential concern for beaches of the Great Lakes given that most beach-front residences employ septic systems for waste-water disposal, large numbers of septic systems are within 50 m of the shore, and groundwater flow below beaches is toward the lake throughout the year. Our study investigated the presence of 18 antibiotics of the three classes (sulfonamides, fluoroquinolones, tetracyclines) in groundwater at a beach on Georgian
Bay, Ontario. Enrofloxacin and levofloxacin were seen at levels up to 300 μg/L 15 m (furthest distance measured) from the tile bed. It is not surprising that antibiotics were detected because they are generally soluble, have a relatively low Kow, and beach sand has low OC content. Our preliminary findings have implications for beaches throughout the Great Lakes including: (1) large numbers of septic systems at beaches = potential large numbers of antibiotic sources and loadings, (2) antibiotics mobility = potential to travel via groundwater to lake, (3) short distance between septic system and lake = potential for antibiotic discharge into lake, (4) ingestion by nearshore organisms = unknown health risks at multiple trophic levels. Keywords: Coasts, Water quality, Pharmaceuticals, Endocrine disruption.

CULVER, D.A.¹ and CONROY, J.D.¹, ¹The Ohio State University, 1315 Kinnear Road, Columbus, OH, 43212; ²The Ohio State University, 1314 Kinnear Road, Columbus, OH, 43212. Twenty Years of Dreissena on Western Basin Lake Erie Hard Substrate – Why is There Any Phytoplankton Left?

Immediately post dreissenid mussel (Dreissena polymorpha and D. bugensis) invasion into Lake Erie 20 years ago, many scientists predicted decreased energy transfer to upper trophic levels due to dreissenid consumption of phytoplankton (PP). However, PP biomass has recently dramatically increased (especially cyanobacteria). Here, we present mussel community structure dynamics (density, species composition, and size-frequency) at 10 hard substrate sites in Lake Erie’s western basin, comparing post-invasion structure with that in 2004; we then assess how structural changes potentially shape mussel-derived effects on PP. We found that June 2004 densities were much less (mean +/- standard error = 3,838 +/- 1,142 mussels m⁻²) than previously reported maximal densities (> 100,000 mussels m⁻²) and were nearly all quagga mussels (98 +/- 1%). With lower densities, recently collected mussels were heavier at a specific length, potentially indicating reduced exploitative competition. However, the mussel community still could have important effects; e.g., calculated mussel nutrient (nitrogen, N, and phosphorus, P) excretion could potentially supply > 50% of PP areal demand for N and < 10% for P. Continued intra-system mussel nutrient subsidy may interact with extra-system nutrient subsidy to facilitate recent increased PP biomass. Keywords: Phytoplankton, Dreissena, Lake Erie.

CVETKOVIC, M. and CHOW-FRASER, P., McMaster University, 1280 Main St. W., Hamilton, ON, L8S 4K1. Relative Importance of Biotic and Abiotic Factors Affecting Species Composition of the Fish Communities in Coastal Wetlands of Eastern Georgian Bay.

Wetlands perform valuable ecological services and host a diversity of organisms, including economically important fish species. This habitat has been increasingly lost since European settlement, and for this reason wetland conservation should be one of the foremost priorities of government and conservation agencies. We have sampled marshes throughout the Great Lakes basin (water quality, fish, and macrophytes), and have found Georgian Bay wetlands to be of outstanding quality and diversity, with numerous sites displaying minimal human impacts. Here we present an overview of the sampling we have completed in the Georgian Bay region, including work done using GIS and remote sensing techniques. Our goals are to summarize both the biotic and abiotic data gathered to date, as well as to evaluate and explore some of the factors affecting fish habitat and composition such as water quality, macrophyte presence and diversity, and exposure. In the future we plan on determining specific relationships between
fish and macrophyte species, fish and the degree of exposure, as well as the effects of declining water levels. The combination of extensive wetland habitat throughout Georgian Bay, high diversity, and low human populations highlights the importance of immediate conservation required for this area. 

*Keywords:* Georgian Bay, Fish, Coastal wetlands.

DA SILVA, A.F.\(^1\) and SZARLETA-YANCY, E.J.\(^2\), \(^1\)Northern Illinois University, Zulauf Hall 415, De Kalb, IL, 60115; \(^2\)Indiana University Northwest, 3400 Broadway, Gary, IN, 46408. **Citizen Participation in Watershed Management: Northwest Indiana as a Case Study.**

Citizens have played an important role in the preservation and restoration of the biologically diverse northwest corner of Indiana. The northwest corner of Indiana contains the Lake Michigan 45 mile watershed. The Lake Michigan watershed contains one of the most industrialized areas of the nation. It is also home to the 7th most biologically diverse national park in the nation, the Indiana Dunes National Lake Shore Park. Citizens played a critical role in the creation of the park. Northwest Indiana is also home to the Grand Calumet River Area of Concern (AOC). This AOC is the only AOC which has been listed as having all 14 Beneficial Use Impairments. Northwest Indiana is a biological community in contrasts. This paper will discuss the efforts of citizens, business, and NGOs to protect and restore the biologically unique and sometimes fragmented corner of the globe. *Keywords: Water quality, Watersheds, Decision making.*

DAHL, T.A. and SELEGAN, J.P., 477 Michigan Ave., Detroit, MI, 48226. **The Right Tool for the Job: Creating a Full Suite of Models to Help the Clinton River Watershed Decrease Sediment Loading.**

The Clinton River drains to Lake St. Clair just north of Detroit, MI. The southern half of this 760 square mile watershed consists of suburban land-use, while the northern portion has historically been agricultural. Recently, however, rapid urbanization has been displacing these agricultural lands, resulting in degradation of the river. A variety of models have been developed to allow community planners to examine sediment issues at multiple scales. These models range from a large SWAT (Soil and Water Assessment Tool) model to examine general areas of sediment production and agricultural best management practices across the entire watershed down to site-specific GSSHA (Gridded Surface-Subsurface Hydrological Assessment) models to look at the effects of subdivision zoning practices, such as lot size and spacing, buffer strips, and rain barrels. Each of these tools has a specific purpose and the full suite of models allows planning authorities to use the most appropriate tool for the job. *Keywords: Sediment load, Sediment transport, Urbanization.*

DAMAIA, S.M. and TODD, K., Ontario Ministry of Natural Resources, 300 Water St., 2nd Floor, Peterborough, ON, K9J 8M5. **Lflow - A Data Collection and Analysis Package to Support Low Streamflow Surveys.**
All divisions of government depend on a common set of base geographic information, such as low streamflow, for water resources studies. Conservation authorities rely on it for conducting water budget studies for Source Water Protection. Municipalities rely on it for evaluating future drinking water supplies. The Ontario Ministry of Natural Resources (OMNR) uses it for fisheries related research and reporting streamflow conditions. Efforts are being made by the MNR to standardize and centralize low streamflow information for data management, retrieval, and reporting needs. The Water Resources Information Program (WRIP) has developed Lflow Beta 1.0, data collection and analysis package, to provide a standard data collection, storage, and analysis environment for low streamflow data. Lflow will serve as a foundation for integrating, analyzing, and sharing low streamflow data easily and consistently. Lflow has been developed around a standard low streamflow measurement methodology established by the Geological Survey of Canada (Hinton 2005). A standard data model and interface has been designed in Microsoft Access™ to simplify data entry functions and calculations. A set of GIS tools has been developed in ESRI ArcGIS™ enabling standard mapping products to be created based on the spatial distribution of low streamflow measurements. Keywords: Ontario Ministry of Natural Resources, Drinking water, Water level.

DE CATANZARO, R. and CHOW-FRASER, P., McMaster University, Dept. of Biology, 1280 Main St. West, Hamilton, ON, L8S 4K1. Use of Ecological Indices to Predict Occurrence and Abundance of Turtle Species in Great Lakes Coastal Marshes.

Ecological indices are crucial assessment tools for evaluating and tracking overall condition of Great Lakes coastal wetlands, many of which have become degraded due to increased nutrient and sediment inputs from agricultural and urban development. Past research in our lab has focused on development of biological indicators to assess wetland quality. Here, we use published ecological indicators, the Water Quality Index and the Wetland Macrophyte Index, to predict occurrence and abundance of vulnerable aquatic species because of their known sensitivity to wetland degradation. Relative abundances of five turtle species were obtained from fish surveys that included turtle by-catch. The surveys were conducted during the summers of 2001 to 2007 inclusive in all Canadian Great Lakes, and sampling was carried out with paired fyke nets, set parallel to shore. Common musk turtle abundance decreased along a gradient of deteriorating wetland quality, while painted turtle abundance as well as total turtle abundance increased. Turtle species richness and abundance of snapping turtle peaked in wetlands of intermediate quality. The results suggest that conservation of sensitive species such as the common musk turtle will become critical as human development continues. Keywords: Indicators, Wetlands, Water quality.

DEKKER, T.J.¹, LAUTENBACH, D.¹, PETERSON, G.W.¹, and SILVER, E.², ¹LimnoTech, 501 Avis Dr., Ann Arbor, MI, 48108; ²Michael Van Valkenburgh and Associates, 18 East 17th St., New York, NY, 10003. Integrating Hydrology, Ecology, and River Geomorphology into Urban Landscape Design: The Lower Don Lands Naturalization Project.

The Lower Don Lands Area of Toronto is located at the intersection of three emerging Toronto neighborhoods: the West Don Lands, East Bayfront, and the Port Lands area. This intersection of
neighborhoods contains the mouth of the lower Don River, a channelized and constrained river mouth surrounded by transportation corridors and other aging urban infrastructure. In recent years, the public demand for restoration of the river mouth area has greatly increased, while the emerging neighborhoods have created a need to find a dynamic balance between the surrounding urban environment and the hydrologic and ecologic requirements of the river mouth. An international design competition to develop a plan for resolving these competing needs was held in 2007. This talk describes how the winning design was developed as a highly multidisciplinary creative effort supported by a strong technical understanding of local hydrology, local freshwater estuarine ecology, and hydrologic and ecological interactions with Lake Ontario. The result is a proposed winding 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, providing sufficient floodwater conveyance capacity to convey the most extreme regulatory flood event. Keywords: Coastal ecosystems, Planning, Hydrogeomorphology.

DEL GOBBO, L.¹, ROBSON, M.E.¹, DIAMOND, M.L.¹, and VANDERLINDEN, L.², ¹University of Toronto, 45 St. George St., Toronto, ON, M5S 2E5; ²Environmental Protection Office, Toronto Public Health, 277 Victoria St., Toronto, ON, M5B 1W1. Lipid Declines in Fish Due to Freezing.

While it is common practice to freeze fish prior to consumption or analysis, freezing can alter the chemical composition of fish. Quality, but not nutritional, decline in fish due to frozen storage has been well documented using biochemical and sensory indices. In this study, the lipid levels in eight fish species expected to exhibit a range of lipid concentrations were monitored over a three week period during which they were stored at -20°C. Total fatty acids (TFA) declined 80-96% in rainbow trout, red mullet, atlantic mackerel, and black cod after 7 days of freezing at -20°C. Saturated fatty acids (SFAs), monounsaturated fatty acids (MUFAs), and polyunsaturated fatty acids (PUFAs) declined at different rates after 7 days of freezing at -20°C. Eicosapentaenoic (EPA) and docosahexaenoic (DHA) acid declines were greatest over the first week of freezing. These results suggest that fish should be consumed fresh (unfrozen) for maximum retention of beneficial lipids such as EPA and DHA, and analyzed fresh to avoid underestimating lipid content in fish. Keywords: Fish, Human health, Chemical analysis.

DELEARY, M.¹, JACKO, N.², and DUCKWORTH, G.³, ¹Womens Water Commission, Union of Ontario Indians, Nipissing First Nation, ON; ²Wikwemikong Unceded Nation, Wikwemikong, ON; ³Aboriginal Affairs Units, Ministry of Natural Resources, Peterborough, ON. Ontario First Nations Perspectives on the Science Strategy of the Great Lakes - St. Lawrence River Basin Sustainable Water Resources Agreement.

Mutually agreeable mechanisms are being developed by the Great Lakes States and Provinces, as part of the Agreement, to facilitate scientific interaction with First Nations and federally recognized Tribes on Agreement components such as the review of major water proposals, understanding of basin water, and groundwater and water conservation. Aboriginal traditional knowledge will be integrated into policies and programs. Ontario First Nations perspectives will be presented by individual speakers, and linkages with Agreement implementation will be highlighted. Mary Deleary, of the Anishinabek Women's Water Commission, will speak to the Commission's advisory role related to Great Lakes management.
She will share some traditional ecological knowledge. Noella Jacko of Wikwemikong Unceded Nation will present results of an inventory of species at risk that was conducted on the shorelands of their reserve on Manitoulin Island. Featured species include Dwarf Lake Iris, Least Bittern, Ram's Head Orchid, Cylindric Blazing Star, and Beach Grass. George Duckworth from MNR Aboriginal Affairs Unit will outline MNR’s strategy to understand aboriginal knowledge of the land and to work with First Nations to collect and use this information in natural resource management. Other speakers may be included.

*Keywords: Water policy, Traditional Ecological Knowledge, First Nations.*

**DELONG, E.J.**, **CAMPBELL, L.M.**, and **MIERLE, G.**


The Ontario Ministry of Environment (OME) has been collecting data on fish tissue mercury (Hg) burdens in lakes and rivers across Ontario since the mid-1970s. Approximately 165,000+ fish from 86 species and 1,600+ sites have been tested for Hg, yielding about 1.5 million database records across Ontario. Currently, many species still exceed Health Canada guidelines for human consumption, particularly those in higher trophic levels. While the OME uses its data primarily for the publication of the biennial *Guide to Eating Ontario Sport Fish* and for the identification of Hg sources, the data also allow for the characterization of historical spatial/temporal patterns of Hg burdens. However, analysis of this long-term environmental dataset is complicated largely by its heterogeneity due to non-systematic sampling methods, and presents a distinct set of challenges. We are applying a model developed by the USGS to standardize the sampling characteristics of the entire database to a single species, length, and cut. We are then able to use a GIS to examine spatial and temporal trends and associations with surrounding biogeochemistry and environmental spatial data. We present our analysis results and discuss the relevance of the trends observed to date.

*Keywords: Mercury, Spatial analysis, Fish.*


Over-lake precipitation is a key component of the Great Lakes water balance. Yet, reliable estimates of such component are difficult to obtain in the Great Lakes region due to the lack of gages in the lake themselves and their sparsity in parts of the draining basin. Traditionally, over-lake precipitation is estimated by distance-weighted and other data-driven methods. In spite of their wide acceptance, such methods suffer from intrinsic limitations as they fail to take into account the spatial and temporal variability of rainfall. Alternative methods for estimating over-lake precipitation include geostatistical interpolation of gage data, doppler radar, assimilation of observed meteorology in numerical weather prediction systems, and different satellite remote sensing techniques. This presentation reviews and compares some of the available products and their applicability in the Great Lakes region. Particular attention will be devoted to the problem of evaluating such products in absence of a "ground truth."
DEPEW, D.C.¹, OZERSKY, T.¹, HOUBEN, A.¹, GUILDFORD, S.J.², HECKY, R.E.², SMITH, R.E.H.¹, and BARTON, D.R.¹, ¹Biology Dept., University of Waterloo, Waterloo, ON, N2L 3G1; ²Biology Dept. and Large Lakes Observatory, University of Minnesota-Duluth, Duluth, MN, 55812 2401. Macrophytes in Cooks Bay: Effects on Water Quality and Nutrient Cycling.

Submerged aquatic macrophytes dominate the benthic producer assemblage in meso-eutrophic Cooks Bay, Lake Simcoe. Excessive macrophyte growth in recent years has presented largely an aesthetic issue, as uprooted plant material accumulated on shorelines adjacent to numerous cottages. Historically, the abundance of macrophytes was attributed to excessive nutrient loading from agriculturally dominated inputs via the Holland River. Studies in the mid 1980s to monitor the response of macrophyte growth to reductions in nutrient loading revealed an increase in growth area and biomass as water clarity increased. The invasion of Lake Simcoe by dreissenid mussels has resulted in further increases in water clarity, potentially expanding the importance of submerged macrophytes in the cycling of nutrients. We report the results of acoustic surveys in 2006 and 2007 designed to estimate the biomass of submerged vegetation in the post-Dreissena era. Keywords: Lake Simcoe, Submerged plants, Phosphorus.


LOTOX2, a PCB mass balance model, has been applied to assist New York State in developing a TMDL for Lake Ontario. Several challenges in developing the TMDL include the varied nonpoint and internal sediment sources of PCBs as a legacy contaminant and varying criteria for human health versus the ecological health of the system used to establish target PCB levels. The major confounding factor for regulatory agencies is that most of the PCB sources are not controllable through existing programs. In order to establish the TMDL and to allocate load reductions fairly to controllable sources in New York, we have applied an approach that assumes uncontrollable and background sources are meeting their fraction of the TMDL load. To do this, baseline PCB loadings (2005) were used to calculate a contribution factor (CF) for each major PCB loading category. The CF was then multiplied by the water quality target to determine the steady-state PCB concentration that must be met by that particular loading component. LOTOX2 was then used to develop a loading response curve at steady-state to determine the allowable load from each loading category. Using the most stringent water quality standard of 1 pg/L, current loadings (2005) from all sources would have to be reduced by 99% in order to meet the criteria. Keywords: PCBs, Lake Ontario, Model studies.

DEPINTO, J.V.¹, VANDERPLOEG, H.A.², and AUER, M.T.³, ¹LimnoTech, 501 Avis Dr., Ann Arbor, MI, 48108, USA; ²NOAA Great Lakes Environmental Research Lab, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105, USA; ³Michigan Technological University, Dept. of Civil and Environmental Engineering, Houghton, MI, 49931, USA. Cladophora and Open-water “Desertification”: Do Dreissenids Play a Role?
Empirical observations and modeling analysis of the ecological impacts of zebra mussels in Saginaw Bay subsequent to their invasion in 1990 have provided considerable knowledge about how dreissenids impact primary production, nutrient cycling, and lower food web dynamics in shallow environments. We have also developed through observation and modeling a good understanding of the environmental conditions that favor *Cladophora* growth in nearshore environments. This presentation will combine these two bodies of knowledge to suggest a hypothesis for how the role of dreissenid filtering-related impacts on water clarity and phosphorus cycling in the nearshore zones of the lakes have fueled the resurgence of *Cladophora* in Lake Michigan, Lake Huron, and Lake Ontario while at the same time greatly reducing the primary production potential of offshore waters in these systems. Dreissenids provide for increased light penetration in shallow areas while at the same time re-mobilizing a sizable portion of the particulate phosphorus in these areas. Both the increased light and available phosphorus lead to lush *Cladophora* growth, which in turn traps a considerable amount of the phosphorus entering the nearshore area from the watershed, greatly reducing production in the offshore waters. 

**Keywords:** Dreissena, Cladophora, Phosphorus.

DERBYSHIRE, D., TONINGER, R., and MCDONALD, K., 5 Shoreham Dr., Downsview, ON, M3N 1S4. **Bird Study in Canada’s Largest 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 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 240 species. Results indicate the site is an important stopover area for migratory birds, comparable to known sites such as Long Point and Point Pelee. Data collected are used to support local land management decisions and regional planning initiatives and are also used to assess continental population changes. The proximity of the research station to Toronto offers great opportunity to engage the public in environmental education. Through education programs, TTPBRS interacts with thousands of visitors on an annual basis. The station represents a unique opportunity to balance fundamental research and public education. 

**Keywords:** Avian ecology, Urban areas, Public education.

DEVANNA, K.M. and MAYER, C.M., University of Toledo - Lake Erie Center, 6200 Bayshore Rd., Oregon, OH, 43618. **Hexagenia Use of Dreissena-colonized Habitat: Opposing Effects of Hypoxia and Fish Predation.**

*Dreissena* affect the distribution and abundance of benthic invertebrates and the flow of benthic energy to fish. It is not clear how the current spread of *Dreissena* onto soft sediment will affect invertebrates such as *Hexagenia*. Preliminary experiments show that *Hexagenia* select for habitat with live *Dreissena* over bare sediment in well-oxygenated water. The goal of this study was to examine two distinct mechanisms that may affect whether or not *Hexagenia* select *Dreissena*-colonized habitat: 1) risk
of predation by fish may promote selection of *Dreissena* habitat, whereas 2) hypoxia may discourage use of *Dreissena* habitat. Laboratory experiments show that *Hexagenia* derive no protection from round goby predation due to the presence of *Dreissena*. However, we hypothesize *Hexagenia* will gain protection from yellow perch predation when burrowed beneath *Dreissena* clusters. Conversely, we found that under low oxygen conditions *Hexagenia* show equal selection for *Dreissena*-covered and bare sediment. *Hexagenia* were also found to leave their burrows during hypoxia. Therefore, short-term periods of hypoxia may increase availability of *Hexagenia* to fish by forcing mayflies to leave their burrows to seek normoxic water. *Keywords: Dreissena, Hexagenia, Benthos, Hypoxia, Invasive species.*

**DIEP, N.K. and BOYD, D., 125 Resources Road, Toronto, ON, M9P 3V6.**  
**Polychlorinated Biphenyl (PCB) Contamination in Wheatley Harbour Area of Concern.**

Muddy Creek, a small wetland system in the Wheatley Harbour Area of Concern (AOC), was identified as an area contaminated with polychlorinated biphenyls (PCBs). Characterization of the vertical and spatial extent of PCBs in Muddy Creek sediment was conducted in 2004 to 2007. PCBs were spatially delineated with higher concentrations along the northeast shore; however maximum PCB concentrations were below the Provincial Sediment Quality Guidelines severe effect level (PSGQ-SEL). Elevated PCB concentrations were observed at discrete locations and with depth, however the area-weight averaged PCB concentration of 2,655 ng/g in the ecologically relevant surficial sediment layer suggests a system moderately contaminated with PCBs. Modeled PCB body burdens in young-of-year fish were found to be consistent with measured concentrations, however site-specific biota-sediment accumulation factors (BSAFs) were generally higher, which suggest PCBs to be more bioavailable and bioaccumulating in benthic invertebrates. Modeled and measured PCB tissue residue in Muddy Creek fish were found to be below the site-specific PCB tissue threshold. We show that though PCB levels in sediment remain consistent over time and are bioavailable, PCBs in Muddy Creek sediment, benthic invertebrates, and fish do not pose a risk to piscivorous wildlife. *Keywords: Bioaccumulation, PCB, Benthos, Area of Concern (AOC), Lake Erie.*

**DIERKS, S.B., JFNew, 605 S. Main St., Suite 1, Ann Arbor, MI, 48104.**  
**The Triple Bottom Line in Watershed Planning: The River Raisin Watershed Management Plan.**

Restoring impaired designated and desired uses to the River Raisin is one of the key driving forces behind the development of the Watershed Management Plan (RWMP). The other major driving force can be summed up as economics, but can also be understood as the complicated relationship between commerce, money, influence, and politics. The two foremost challenges for the River Raisin are closely connected. The first challenge is that agriculture, the watershed’s primary economic engine, is also the industry/land use causing most of the water quality impacts. The second challenge is the poor public perception of the river. To address these challenges, the connection between the land and the river has to be understood not only in ecological terms but also in terms of economic and social impact. We believe the key here is to achieve the triple bottom line---economic and ecological sustainability as well as social equity---by making agricultural viability and ecological integrity simultaneous and inter-related goals. The major assumption in the River Raisin Watershed Management plan is that a healthy local economy
will actually help foster a healthier ecology. This plan includes recommendations that fall outside of typical Best Management Practices in order to help build local economic resources that will foster ecological restoration. *Keywords: Triple bottom line, Agricultural watershed, Sustainability.*

DOBIESZ, N.E.¹ and LESTER, N.P.², ¹UMN Duluth-109 Research Lab Building, 2205 E. 5th St., Duluth, MN, 55812; ²OMNR, DNA Bldg., Trent University, 2140 East Bank Dr., Peterborough, ON, K9J 7B8. **The Importance of Long-term Datasets: A Case Study from the Great Lakes.**

Ongoing monitoring programs provide data to build long-term datasets, but insufficient funds to support these programs or changes in management directives can affect the collection of these data. This presents special challenges to researchers studying long-term trends. We compiled limnological data from government agencies in the U.S. and Canada who sampled Lakes Huron, St. Clair, Erie, and Ontario between 1968 and 2002. The final compilation included over 15,000 stations yet despite the large database, temporal and spatial gaps occurred. The number of samples per month decreased over time such that 42% of the samples occurred between 1970 and 1979, 35% occurred between 1980 and 1989, and 23% occurred between 1990 and 2002. Notable exceptions to this pattern occurred in Saginaw Bay, Lake Huron, and Lake St. Clair where observations increased in response to zebra mussel invasion. Spatial gaps occurred when stations were grouped by depth. There were 79% more Secchi depth samples in the offshore (depth >10 m) than nearshore segments across 10 basins representing an additional 15 years of offshore data. We examine how this research was impacted by the limitations of the long-term datasets and discuss the importance of ongoing monitoring for future research. *Keywords: Monitoring, Data acquisition, Great Lakes basin.*

DOLAN, D.M.¹, RICHARDS, R.P.², and PIETTE, C.M.¹, ¹University of Wisconsin - Green Bay, 2420 Nicolet Dr., Green Bay, WI, 54311; ²National Center For Water Quality Research, Heidelberg College, Tiffin, OH, 44883. **Updated Total Phosphorus Load Estimates for Lake Erie , 2005-2007.**

Although it is the smallest of the Great Lakes, Lake Erie receives the greatest loading of total phosphorus. It has the largest GLWQA target load of any of the lakes (11,000 metric tonnes per annum) and the target can be exceeded due to continued inputs from urban and rural sources. The Ohio Tributary Monitoring Network established by the National Center for Water Quality Research at Heidelberg College continues to collect one to three samples per day for nutrients and sediment at sites on six Lake Erie tributaries. The resulting total phosphorus data from this program combined with other data sources allow for the estimation of daily load time series required by ecosystem modelers at the NOAA-Great Lakes Environmental Research Laboratory for the ECOFORE 2006 project. The loads are still reported by Lake Erie basin (western, central, and eastern) and can be aggregated to the level of total lake loading for comparison to the GLWQA target. Starting in 1999, the Lake Erie total phosphorus loads have been consistently below the GLWQA target, but preliminary estimates indicate that the target was approached or exceeded in 2006 and 2007. *Keywords: Phosphorus, Lake Erie, Pollution load.*
DOVE, A.E., Canada Centre for Inland Waters, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Trace Organic Contaminants in the Open Waters of the Laurentian Great Lakes - How Low Can We Go?**

As part of its Surveillance Program, Environment Canada conducts water quality monitoring on each of the binationally-shared Great Lakes. Since 1988, this monitoring has included a suite of organic contaminants. An ongoing challenge has been to measure the very low concentrations of many of these parameters in the open waters of the Great Lakes. Over the years, we have made improvements to the sampling methods, sample handling, and laboratory analysis to reduce sample contamination. Since 2003, we have been using a new sampling platform called the PoPCart, and samples are now extracted in an ultra-clean laboratory at the Canada Centre for Inland Waters in Burlington, Ontario. In this talk, an overview of the spatial distribution of dissolved phase organic contaminants will be presented for each of the Great Lakes. The organic compounds include organochlorine (OC) pesticides (including PCBs), polycyclic aromatic hydrocarbons (PAHs), and certain currently-used pesticides. An overview of spatial trends is provided, and the current levels (2004 – 2006) are compared to those measured in the past (1988 – 2001). **Keywords:** Organic compounds, Water quality, Great Lakes basin.

DRAKE, A.¹, MANDRAK, N.E.², and HARVEY, H.H.¹, ¹Department of Ecology and Evolutionary Biology, University of Toronto, Toronto, ON, M5S 3B2; ²Centre of Expertise for Aquatic Risk Assessment, Great Lake Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, Burlington, ON, L7R 4A6. **Quantifying the Spread of Aquatic Invasive Species, Genes, and Pathogens: The Baitfish Industry in Ontario as a Model Pathway.**

Aquatic invasive species (AIS), genes and pathogens have negative impacts on the ecological and economic integrity of Canadian freshwaters, particularly within the Laurentian Great Lakes. Typically, introductions of AIS, genes, and pathogens require an invasion pathway. Determining the risk of introduction and spread through an invasion pathway can be advantageous to resource managers because the process encompasses multiple species of concern, contrary to traditional single-species risk assessment approaches. Although the shipping industry and associated practice of ballast-water release is one pathway responsible for the introduction of AIS into Canadian freshwaters (specifically, the Laurentian Great Lakes), additional pathways exist that have the potential to transport AIS, genes, and pathogens further inland, to uncolonized waters. The baitfish industry in Ontario is one such pathway. Using a probabilistic, spatially-explicit modeling approach, we determine areas at-risk of species, gene, and pathogen introduction based on angler movement metrics, thus determining areas that should be prioritized for AIS prevention management. **Keywords:** Invasive species, Model studies, Risk assessment.

DUCKETT, F.¹, FULLARTON, M.¹, LU, Q.¹, and GOODYEAR, D.², ¹627 Lyons Lane, Suite 200, Oakville, ON, L6J5Z7; ²Lake Simcoe Region Conservation Authority, 120 Bayview Parkway, Newmarket, ON, L3Y4X1. **Numerical Modeling in Support of Source Water Protection Zone Delineation on Lake Simcoe.**

Lake Simcoe is the source of drinking water for thousands of people who live in the many communities around the lake. There are six municipal water treatment plants located on Lake Simcoe.
The lake is also the recipient of outflows from sewage treatment plants, industry, and storm water runoff. In 2006, the Ontario government introduced legislation to protect drinking water. This requires the production of locally developed, science based source water protection plans, including a Surface Water Vulnerability Analysis, in which surface water areas that may be vulnerable to contamination are identified. The delineation of the intake protection zones provides important insight into the competing and often conflicting uses of this resource. Numerical modeling was used to delineate intake protection zones for the six municipal intakes on Lake Simcoe. In each case, input from the water treatment plant (WTP) operator was used to identify threats, issues, and a time required to shut down the WTP in the event of a spill. The Intake Protection Zones were delineated based on the WTP shut down time and the current velocities in the lake and surrounding tributaries. Current velocities in the lake were established using DHI’s MIKE3, 3-dimensional numerical model. *Keywords: Lake Simcoe, Hydrodynamic model, Water quality.*

DUMOULIN, D., Ontario Ministry of Natural Resources, Water Resources Section, 300 Water St., 5th Floor, S. Tower, Peterborough, ON, K9J 8M5, Canada. **Calculating the Consumptive Use of Water Withdrawals in the Great Lakes Basin – Status of Current Methodologies and Recommendations for Enhancement.**

Since 1985, a variety of coefficients and calculations have been used to estimate the consumptive loss associated with water withdrawals in the Great Lakes basin, as required by the Great Lakes Charter. In December 2005, the Premiers of Quebec and Ontario along with the governors of the 8 Great Lake states signed the Great Lakes – St. Lawrence River Basin Sustainable Water Resources Agreement which committed to manage, regulate, and collect and share information on water withdrawals, diversions, and consumptive uses. The consumptive use figures currently used by many jurisdictions are not widely supported and are out of date with improved science and climate change being contributing factors. The government of Ontario hired a consultant to conduct a synthesis of current consumptive use practices, and recommend steps for improvement. This presentation will highlight the findings of the research and demonstrate how the parties to the Agreement can work together to refine current mechanisms. *Keywords: Measuring instruments, Great Lakes basin, Consumptive water use.*

DYBLE, J.¹, FAHNENSTIEL, G.L.¹, and MILLIE, D.F.², ¹NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 48105; ²Florida Institute of Oceanography, University of South Florida, St. Petersburg, FL, 33701. **Cyanobacterial HABs in the Great Lakes: Environmental Stressors, Genetic Diversity and Impacts on Human Health.**

There are many potential threats to human health that may result from the proliferation of harmful algal blooms in the Great Lakes. These include exposure through drinking water supplies (e.g., use of untreated water for drinking, chronic exposure through low levels of toxins in treated sources), recreation (e.g., inhalation of aerosolized toxins while boating, accidentally swallowing water while swimming), and food (e.g., bioaccumulation in fish). We will summarize what is currently known about the distribution, abundance and genetic diversity of *Microcystis* in the lower Great Lakes, as well as environmental factors influencing microcystin production and the potential for accumulation in edible fish tissue. We will...
discuss the implications of this data on human health in the Great Lakes region and identify areas requiring further investigation. **Keywords:** Harmful algal blooms, Microcystis, Human health.

**EDGE, T.A.**¹, KHAN, I.¹, WATSON, S.B.¹, BOOTY, W.G.¹, YERUBANDI, R.R.¹, and MOORE, L.², ¹National Water Research Institute, 867 Lakeshore Road, Burlington, ON, L7R 4A6, Canada; ²Ontario Clean Water Agency, Toronto. **Occurrence of Waterborne Pathogens at Offshore Drinking Water Intakes in Lake Ontario.**

The Collaborative Study to Protect Lake Ontario Drinking Water began field studies in 2007 to investigate the occurrence of waterborne pathogens at offshore drinking water intakes in Lake Ontario. Preliminary investigations have focused on *Campylobacter* and *Aeromonas* species, as well as indicator organisms like *E. coli*, *Enterococcus*, *Clostridium perfringens*, and a *Bacteroides* DNA marker for human fecal pollution. A Lake-wide cruise in August found that bacterial water quality indicators were rarely detected in water samples collected more than about two km offshore. A pilot study near the mouth of the Credit River has found that offshore intake water at four nearby drinking water plants typically has low numbers of *E. coli* (< 5 CFU/100 mL), and only rare occurrence of *Campylobacter* species and the human *Bacteroides* DNA marker. However, *Campylobacter* and the *Bacteroides* marker were detected at all four intakes, and *E. coli* numbers were above Ontario Provincial recreational water quality guidelines (100 CFU/100 mL) several times. Preliminary results raise questions about the occurrence of more persistent waterborne pathogens like enteric viruses and protozoa. They also stress the importance of maintaining sound water treatment practices. **Keywords:** Drinking water, Human health, Lake Ontario.

**EDWARDS, W.J.**¹, SOSTER, F.², MATISOFF, G.³, SCHLOESSER, D.⁴, and BANTELMAN, A.¹, ¹DePaul Hall, Niagara University, Lewiston, NY, 14109; ²Department of Geosciences, DePauw University, Greencastle, IN, 46135; ³Department of Geological Sciences, Case Western Reserve University, 112 A.W. Smith Bldg., 10900 Euclid Ave., OH, 44106; ⁴USGS Great Lakes Center, 1451 Green Rd., Ann Arbor, MI, 48105. **Oxygen Dynamics within Chironomus spp. Burrows and the Potential Impact on Lake Erie Central Basin Seasonal Hypoxia.**

Chironomids may contribute to hypoxia in the central basin of Lake Erie due to high densities and burrow water pumping activities. We quantified burrow water oxygen concentrations and flow velocities, and the enhanced oxygen transport into the sediment. Chironomids were collected from Lake Erie during summer and 3rd and 4th instars were placed in 2D mesocosms at 9°C and 25°C. We determined oxygen concentrations and flow velocities using micro-oxygen electrodes and hot wire anemometry. Burrow dimensions were analyzed via x-radiography. Oxygen depletion in burrow water correlated with increased pumping events and velocities, increasing the oxygen flux into the sediment. Enhanced solute exchange between sediments and water was demonstrated by tracing a bromide spike added to the overlying water. A model that assumes diffusive transport across the sediment-water interface and radial diffusion into the sediment from an irrigated burrow describes bromide data reasonably well. The larvae changed burrows more frequently, had less peak effect on oxygen flux, but had a more regular pumping activity than previously studied mayfly nymphs. Further work should include field testing laboratory results with
burrows in intact lake sediment cores and macrobenthos abundance surveys to quantify the effects of chironomids on SOD. Keywords: Oxygen, Biogeochemistry, Benthos.

EFFLER, S.W.¹, PENG, F.¹, O’DONNELL, D.M.¹, PERKINS, M.G.¹, STRAIT, C.M.¹, and LESHKEVICH, G.²¹,¹ Upstate Freshwater Institute, PO Box 506, Syracuse, NY, 13214; ²NOAA/Great Lakes Environmental Research Laboratory, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105. 

Minerogenic Particles and Light Scattering in Lake Ontario and Pursuit of Optical Closure.

Light scattering particles are important regulators of optical metrics of water quality, such as Secchi disc depth (ZSD), and the signal available for remote sensing. The role of inorganic, or minerogenic, particles in light scattering in Lake Ontario (seven pelagic sites, August 2007) was evaluated based on the results of individual particle analyses, by scanning electron microscopy interfaced with automated x-ray microanalysis and image analysis (SAX), and in situ bulk measurements of particle scattering (bₚ) and backscattering (bₛₚ) coefficients. SAX quantified the light scattering features of these particles, including concentration, composition, size distribution, and supported Mie theory estimates of the minerogenic components of bₚ and bₛₚ. These estimates, added to those obtained for the organic component based on chlorophyll a concentrations, closed well with the bulk measurements. Spatial differences in the minerogenic particle population, with respect to concentration and composition, were primarily responsible for the substantial spatial structure observed for bₚ, bₛₚ, and ZSD, and MODIS (satellite-based) measurements of normalized water-leaving radiance. Keywords: Lake Ontario, Remote sensing, Underwater optics.

EVANS, D.O.¹, SKINNER, A.J.¹, YUNKER, G.B.¹, WINTER, J.G.², and LA ROSE, J.K.L.³¹,¹ Ontario Ministry of Natural Resources, Trent University, 2140 East Bank Road, Peterborough, ON, K9J 7B8; ²Ontario Ministry of Environment, 125 Resources Road, Toronto, ON, M9P 3V6; ³Ontario Ministry of Natural Resources, LSFAU, 26465 Hedge Road, RR #2, Sutton West, ON, L0E 1R0. 

Hypolimnetic Temperature and Dissolved Oxygen in Lake Simcoe Before and After Invasion by Zebra Mussels and Implications for Lake Trout.

Degradation of spawning habitats and hypoxic conditions in the hypolimnion are the suspected primary causes of complete recruitment failure of wild lake trout in Lake Simcoe. The native lake trout has been maintained for several decades by annual stocking. Our objective is to document hypolimnetic temperature and dissolved oxygen conditions before and after establishment of zebra mussels. We also address other interacting factors, including external loading of phosphorus (P), changing predator-prey relationships and climatic variation that are also influencing conditions for lake trout in Lake Simcoe. A significant improvement in water quality occurred following the invasion and establishment of zebra mussels during 1994-96 and a few wild lake trout recruits have been observed each year since 2001. Prior to 1996 mean volume-weighted hypolimnetic dissolved oxygen (MVWHDO) in the central basin, adjusted to September 15, was 2.5 mg/L (n=21 yr) which was below the incipient lethal threshold of 3.0 mg/L for young lake trout. After 1996 MVWHDO on September 15 increased to 4.6 mg/L (n = 11 yr) and since 2002 has exceeded 5.0 mg/L. Declines in P loading have also accompanied these improvements.
Recent changes in water quality and initial renewed natural recruitment of lake trout provide evidence that ecosystem recovery is possible. Keywords: Lake Simcoe, Lake trout, Water quality.

EVANS, M.A. and LITCHMAN, E., W. K. Kellogg Biological Station, Michigan State University, Hickory Corners, MI, 49060. Physical and Biological Controls on Abundance of Microcystis, a Harmful Algal Bloom (HAB) Species.

Microcystis and other buoyant, toxin producing algae are sensitive to changes in lake turbulence and light availability, thus climate change may effect the occurrence of such harmful algal blooms (HABs). Simultaneous changes in lake nutrient, zebra mussel (ZM), and transparency status may also effect algal competition. A survey of 28 Michigan lakes, ranging in size from 1.8-830 ha, and containing approximately paired gradients of nutrient levels with and without ZMs, showed that Microcystis bloomed in low nutrient lakes (TP < 20 μg/L) only in the presence of ZMs. Results of this survey, combined with weekly monitoring results from Gull Lake, MI (surface area 830 ha, ZMs present, TP 5 μg/L), were compared to a previously published model of HAB formation based on turbulence and light competition. This model was an insufficient predictor of Microcystis abundance in low nutrient lakes, predicting blooms where none were observed. Moderately strong Microcystis blooms were observed, with particle attached microcystin toxin concentrations reaching 6 μg/L in open surface waters and >10x higher concentrations near shore in protected bays. Empirical results indicate that turbulence, light, nutrients, and ZMs must all be included in a Microcystis model for lakes in the Great Lakes region. Keywords: Mathematical models, Climate change, Harmful algal blooms.

FAGAN, K.M.¹, KOOPS, M.A.², ARTS, M.T.³, SUTTON, T.M.⁴, and POWER, M.¹, ¹Department of Biology, University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1; ²Great Lakes Laboratory for Fisheries and Aquatic Sciences, Department of Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; ³National Water Research Institute, Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; ⁴School of Fisheries and Ocean Sciences, University of Alaska, Fairbanks, AK. The Effects of Trophic Disruption on the Diet and Condition of Lake Whitefish.

Lake whitefish Coregonus clupeaformis, a commercially important fish, has experienced declines in condition in some areas of the Great Lakes. It has been hypothesized that trophic disruption has led to declines in the abundance of high quality food resources, specifically Diporeia. Spawning lake whitefish were sampled in 2004 and 2005 at six stations around Lake Michigan and one station each in Lakes Superior and Erie known to vary in local abundances of Diporeia. Lake whitefish condition was characterized using dorsal muscle total lipid and the hepato-somatic index (HSI). Mean total lipid levels were significantly different between lakes in 2004 and 2005, with high mean values of 38% and 35% in Lake Erie. Male HSI was found to be significantly different between lakes each year, with high mean values of 0.89 and 0.85 in Lake Superior. Female HSI was significantly different between lakes only in 2004, with a high mean of 1.26 in Lake Erie. The condition of lake whitefish was greatest in Lakes Erie and Superior, with low and high Diporeia abundances, respectively. Further research is aimed at
establishing the linkage between condition and isotope values to understand the relative reliance of lake whitefish on Diporeia at the various sites. Keywords: Great Lakes, Lake whitefish, Trophic disruption.

FANG, T., CAMPBELL, L.M., WANG, Y.X., COLE, L., and CHAN, W.W., School of Environmental Studies, Queen's University, Biosciences Complex, Kingston, ON, K7L 3N6, Canada. Assessing Human Exposure from Mercury in Fish from East China Lakes.

Because of the rapid industrial development and the importance of freshwater fish in the Chinese diet, the contaminations of mercury and other metals is being increasingly concerned. In May 2005, two species of catfish and two species of carp were sampled at local fish markets near 4 Chinese lakes. Mean total Hg concentrations, in mg/kg, were observed in the following order: Qiandao Lake (0.688) > Xinshan Lake (0.615) > Dongting Lake (0.173) > Tai Lake (0.071). The total Hg in fish from Qiandao Lake and Xinshan Lake were above the Chinese contamination limit (0.300). In May 2006, a deeper study measured the concentration of total Hg and other metals (Cr, Cu, Co, Ni, Cd, Pb, Zn, Rb, Cs) in dorsal samples from two species of wild fish, southern catfish and yellow catfish, and two species of farmed fish, bluegill and channel catfish at Qiandao Lake. All fish are contaminated with mercury but only the total Hg concentrations of southern catfish (1.917) and yellow fish (0.629) were above the Chinese contamination limit. At this level of contamination, frequent consumption of these fish could be detrimental to the health of human consumers. Current data have been used to evaluate the human risk for Qiandao Lake. Furthermore, human risks related to fish consumption around the Qiandao Lake will be the focus of our following work since many commercial fish are farmed there. Keywords: Mercury, Fish, Risk assessment.

FATHI, M.1, BLAIS, J.M.1, LEAN, D.R.S.1, and RIDAL, J.J.2, 1Department of Biology, University of Ottawa, Ottawa, ON, K1N 6N5; 2St. Lawrence River Institute, Cornwall, ON, K6H 4Z1. Benthic Flux of Total Mercury (THg) and Methyl Mercury (MeHg) between contaminated Sediments and the Overlying Water Column in the St. Lawrence River near Cornwall, Ontario.

The toxicity, bioaccumulation potential, and flux of mercury depends on its chemical form. Methyl mercury (MeHg) is considered to be the most toxic form and the only form to biomagnify in the aquatic food web. The St. Lawrence River near Cornwall, Ontario was designated an Area of Concern by the IJC in 1985 because of its contamination with mercury and other metals by local industry. This study investigated the potential for benthic flux of mercury between contaminated sediments and overlaying water. It is recognized that some mercury species are more mobile than others. We measured concentrations of total Hg (THg) and MeHg in both the porewater and solid phase of the sediments, and in overlaying water to determine whether these sediments are acting as a source or sink for Hg and compared values with complimentary redox-sensitive variables, including sulphate, sulphide, and Fe2+ distributions. We calculated flux rates of MeHg and THg from sediments to water, and compared these with THg accumulation rates determined from radiometrically dated sediment cores. Although sediments were a net sink for THg, the flux of MeHg to the overlying water was positive but very low. There was little seasonal variation in MeHg flux rates. Keywords: Mercury, Sediments, St. Lawrence River.
FENICHEL, E.F.\textsuperscript{1}, TSAO, J.I.\textsuperscript{2}, and JONES, M.L.\textsuperscript{1}, \textsuperscript{1}Department of Fisheries and Wildlife, The Quantitative Fisheries Center, 13 Natural Resource Bldg., East Lansing, MI, 48864; \textsuperscript{2}Department of Fisheries and Wildlife, Department of Large Animal Clinical Sciences, 13 Natural Resources Bldg., East Lansing, MI. **Epidemiological Models Can Guide Fish Health Research and Management: Bacterial Kidney Disease in Free-swimming Fish.**

Mechanistic epidemiological modeling has provided a useful approach to organize knowledge and improve understanding of host-pathogen dynamics in wild terrestrial populations, but has not been applied to freshwater systems. We introduce epidemiological modeling and illustrate how it can aid fishery managers. *Renibacterium salmoninarum* (Rs), the causative agent of bacterial kidney disease, has been hypothesized to have played a role in the decline of salmonids in Lake Michigan in the '80s, yet little is known about its dynamics outside of hatcheries. We developed a susceptible-exposed-infected-exposed (SEIE) model to simulate disease dynamics in wild and hatchery-spawned Chinook salmon (Oncorhynchus tschawytscha) among different epidemiological classes. We included age-structure, an environmental reservoir and various hatchery management scenarios. Results suggest that stocking fewer healthier fish can lead to larger harvestable populations versus stocking more infected fish. Also, Rs prevalence patterns may help distinguish outbreaks driven by overall population density versus by stocking infected fish. Model results reveal the need to understand wild recruitment patterns in Lake Michigan Chinook salmon, the extent of vertical transmission, and the mechanisms by which exposed fish become infectious. **Keywords:** Mathematical models, Fish diseases, Fish populations.

FENICHEL, E.F.\textsuperscript{1}, TSAO, J.I.\textsuperscript{1}, JONES, M.L.\textsuperscript{1}, and HICKLING, G.J.\textsuperscript{2}, \textsuperscript{1}Michigan State University, Department of Fisheries and Wildlife, East Lansing, MI, 48824; \textsuperscript{2}University of Tennessee, Department of Forestry, Wildlife and Fisheries, Knoxville, TN, 37996. **How Many Fish to Screen – No Easy Answer.**

Aquatic pathogens have risen to the forefront in Great Lakes Fishery Policy. Along with this rise, there is increasing recognition of the need to more fully integrate fish health into fisheries management. Nowhere is this more apparent than for the perennial question of how many fish to screen for pathogens. This question has generally only been addressed based on statistical concerns without consideration of more fundamental management issues such as objectives and management opportunities. Screening is an investment in information. Therefore, the value of that information is critical in deciding how many fish to screen. This value of that information is in turn a function of other management opportunities. We present a conceptual framework that links disease ecology, population dynamics, economics, and statistics for thinking about the screening question within the context of fishery management. Then, we review the underlining statistical concepts behind screening design to show how statistics alone can not tell us how many fish to screen. Finally, we highlight opportunities that we believe offer the first steps toward integration of screening for aquatic pathogens into a systems approach to fishery management. **Keywords:** Fish diseases, Risk assessment.

FILATOV, N.\textsuperscript{1}, RUKHOVETS, L.A.\textsuperscript{2}, TERZHEVIK, A.\textsuperscript{1}, and ASTRAKHANTSEV, G.P.\textsuperscript{2}, \textsuperscript{1}Northern Water Problems Institute, Karelian Research Centre, Russian Academy of Sciences, 50 Aleksander

Lakes Ladoga (surface area = 17,891 km²; volume = 902 km³) and Onego (surface area = 9,600 km²; volume = 292 km³) are the greatest lakes in Europe. Lake Ladoga ranks among the top fifteen world’s freshwater lakes and is comparable with the surface area of Lake Ontario. The watershed of Lake Ladoga (258,000 km²) extends through northwestern European Russia and the eastern part of Finland, including the large lakes of Ilmen and Saimaa. Lakes Ladoga and Onego are an important link in the Kaspian-Baltic-White Sea waterway system. Their ecological state affects the water quality of Neva River, Gulf of Finland, and the Baltic Sea, and is strongly related to drinking, recreational, transportation, and energy uses. It is not surprising that changes in the ecological state of Lakes Ladoga and Onego attract attention of institutions dealing with operational use, environmental protection, and management of water resources not only in Russia, but also in trans-boundary countries. Lake Ladoga preserves its weak mesotrophic status, and Lake Onego can be characterized as oligotrophic. Economical growth during the last seven years led to the increasing anthropogenic impact on the ecosystems of these lakes.

Keywords: Ecosystem health, Environmental policy, Management.


Eastern sand darter (Ammocrypta pellucida) is listed as a threatened species under Canada’s Species at Risk Act (SARA). Habitat destruction throughout its geographic range has made the species vulnerable to population declines and possible local extinction. To help protect eastern sand darter, biological recovery teams mandated by SARA have identified knowledge gaps in scientific understanding of the life-history and population ecology of the species. Population modeling has been highlighted as one method that can help determine population fates and identify critical population habitat and life stages. However, population modeling can be difficult to apply when little is known about population vital rates and life-history variation. Here, I discuss the calculation of vital rates (e.g., mortality, growth, and recruitment) for use in the construction of a stage-based population model for eastern sand darter on the lower Thames River. Information for vital rates comes from a variety of sources including; field studies, habitat surveys, and aging studies. Emphasis has been placed on using non-lethal sampling methodologies due to eastern sand darters’ SARA classification. Anticipated outcomes of the model include; estimation of population trajectories and identification of limiting life-stages. Keywords: Matrix modeling, Population dynamics, Species at risk.
Recent investigations identified that the current watershed management efforts used in the Great Lakes basin have led to an expansion of submerged aquatic vegetation (SAV) such as rooted plants and filamentous algae across lake and river habitats. It is clear that this expansion of SAV across habitats is due to improved water clarity. Investigations also revealed that expanded SAV usually involves native species. The expansion of SAV was an expected outcome of the Great Lakes Water Quality Agreement but also represents a major management challenge. Currently, a range of direct and indirect activities are used to manage SAV across habitats. Direct activities include harvest and protection of SAV, and indirect activities include detailed monitoring of phosphorus loading and limits on shoreline development to shape SAV communities. This presentation will review the status of SAV expansion across the Great Lakes basin and identify the different management activities currently used in rivers, ponds, and lakes. Case studies will be used to highlight these management activities. Additional management activities for SAV in use for locations beyond the Great Lakes basin will also be considered. Keywords: Management, Benthic flora, Review.

FOX, B.M., 120 Bayview Parkway, Box 11, Newmarket, ON, L3Y 4W3. Conservation Authorities and the Engagement of the Watershed Community in Canadian AOCs.

Conservation Authorities are community-level organizations that manage natural resources on a watershed basis across Ontario; each Conservation Authority is governed by a Board of Directors whose members are municipally appointed. Thirty-five CAs drain into the Great Lakes/St. Lawrence system and, through their mandate for watershed management, they are important partners to enhancing and maintaining water quality and overall health of the Great Lakes. Of the seventeen Canadian (includes three bi-national) Areas of Concern (AOCs), twelve are encompassed within the watershed boundaries of CAs and these CAs, in partnership with others, are implementing remedial actions. Additionally, in five of these twelve AOCs the CAs have a leadership and coordination role for the Remedial Action Plans and associated actions for the Toronto Harbour (Metro Toronto), Hamilton Harbour, Niagara River, Bay of Quinte, and the St. Lawrence River (Cornwall) AOCs. Projects utilizing CA expertise have included urban and rural non-point source pollution remediation, habitat restoration, storm water and wastewater management, and community engagement. A few projects will be highlighted to demonstrate the role and value of engaging the watershed community in restoring and delisting the AOCs, as well as to explore “potential” opportunities. Keywords: Watersheds, Public participation, Community engagement, Conservation authorities.

The breakdown of leaf litter is a significant part of stream ecosystems because it provides energy to food webs, provides habitat, and is important for particle transport in the stream. We tested leaf litter decomposition for two riparian (speckled alder and red maple) and two crop (alfalfa hay and wheat straw) plants in ten streams of the Laurentian Great Lakes basin ranging in agricultural land use from 1.5 to 75%. Decomposition was higher in plants that were rich in nitrogen (alder and maple) compared to crop plants which contained much less nitrogen. Streams with more agricultural landuse in the catchment showed faster rates of decomposition, likely associated with higher nutrients (nitrogen and phosphorus). Preliminary results show that decomposition rates of leaf-litter bundles are positively related with invertebrate richness and abundance. Understanding how decomposition rates differ between plant species and between streams with varying agricultural activity is important for understanding the changes to stream functions associated with land use alterations. Keywords: Land use, Leaf litter decomposition, Macroinvertebrates.

FREEMAN, A.D. and MONTGOMERY, K.E., 5 Shoreham Dr., Downsview, ON, M3N 1S4. Involvement in the Toronto and Region Remedial Action Plan.

Restoring environmental conditions in a place developing as fast and growing as large as Toronto and region is a task beyond the scope of one group. Fortunately, in Toronto and region, there are many groups and agencies working to enhance environmental conditions. Initial planning for the Toronto and region Remedial Action Plan (TORRAP) involved a Public Advisory Committee (PAC). With the plan completed combined with the need to focus on implementation, and the era’s funding cuts, the PAC was dissolved; however, this did not mean the end of public input into the RAP, only the arrangement changed. Watershed advisory committees were established to assist with the development and implementation of watershed plans. Over 200 people participate on these watershed committees which are comprised of residents, government agencies, municipalities, industries, and community groups. TORRAP supports these activities as they ensure a venture for open input to the RAP while fulfilling the role of the PAC. Functioning in the same manner as a PAC, these committees successfully assist in securing resources, influencing priorities, and establishing linkages within the community, operating on a watershed scale. Keywords: Urban watersheds, Environmental policy, Community involvement.


The Blue Flag is a respected international eco-certification program for beaches. Operated internationally by the Foundation for Environmental Education, a Blue Flag symbolizes a clean beach which meets strict international standards. Environmental Defence is an Associate Member of FEE and the Canadian operator of the program. The program is a voluntary certification scheme, proven to be a practical management tool to assist and facilitate the implementation of environmental policies and strengthen their effective implementation. Certification requires the assessment of a beach against 27 standards categorized as water quality, environmental education, environmental management, and safety and services. Local and national stakeholders are involved to ensure all facets of the coastal environment are represented. The goal is to empower communities to educate community members, improve and
sustainably manage their coastal ecosystems. Blue Flag fosters the necessary education and actions required to ensure a sustainable, prosperous future for our Great Lakes/coastal ecosystems. These factors illustrate that the Blue Flag is a unique approach to sustainably managing our coastal ecosystems. The oral presentation will provide an overview of the program and how it contributes to an ecosystem based approach to managing the Great Lakes. Keywords: Coastal ecosystems, Lake ecosystems, Education, Human health, Water quality.

FUCHSMAN, P.¹, HENNING, M.², LEIGH, K.¹, and WELSH, P.³, ¹ENVIRON International Corp., 13801 West Center St., Suite 1, Burton, OH; ²ENVIRON International Corp., 136 Commercial St., Suite 402, Portland, ME, 44021; ³Ontario Ministry of the Environment, Standards Development Branch, 40 St. Clair Ave. West, 7th Floor, Toronto, ON, M4V 1M2. Innovative Evaluation of Risks to Mink from PCBs in Muddy Creek, Wheatley Harbour Area of Concern, Lake Erie, Ontario.

Wheatley Harbour is one of 43 Areas of Concern identified in the Great Lakes Water Quality Agreement. Polychlorinated biphenyls (PCBs) in sediment and biota of the Muddy Creek portion of Wheatley Harbour are attributed to historical discharge of wastewater and disposal of fish offal by nearby fish processing plants. An ecological risk assessment was conducted for Muddy Creek to determine whether sediment remediation is warranted to mitigate risks from PCBs to piscivorous wildlife. Of the receptors evaluated, mink are the most toxicologically sensitive to PCBs and offer the greatest opportunity for site-specific, innovative, and accurate evaluation. Local mink survey information was used to select representative foraging ranges, area use factors, and fraction of diet as fish. Dietary concentrations in fish were characterized based on measured and modeled fish tissue concentrations. Exposure and effects were characterized based on dietary doses, as well as estimated internal doses or body burdens. Because both methods concluded that mink are not likely to be adversely affected by PCBs in Muddy Creek sediment and fish, the ecological risk assessment concluded that sediment remediation in Muddy Creek is not warranted. Keywords: PCBs, Risk assessment, Mink.

GEFELL, D.J. and HUGHES, D.J., Onondaga Environmental Inst., 102 W. Division St., 3rd Floor, Syracuse, NY, 13210. An Integrated Assessment of Water Quality in Onondaga Creek, Syracuse, New York.

Onondaga Creek, a tributary of Onondaga Lake, has played a central role in the history of aboriginal (Onondaga) and western cultures in central NY. The creek watershed (~300 km²) progresses from mixed forests, agricultural (esp. dairy and orchards), to heavily urbanized land. We have undertaken a comprehensive assessment of physical (sediment loading, temperature), biological (fish, macroinvertebrate, indicator bacteria), surface water (diss. oxygen, phosphorus, salinity), and sediment data collected by multiple agencies. Moving along the rural-to-urban gradient, creek habitat generally deteriorates, while fish community health (IBI) and macroinvertebrate scores decrease. The creek continues to be adversely affected by very high sediment loading from rural sources; salinity is elevated, due to both natural and human sources; and temperature is inhospitable to native and stocked trout in certain areas. D.O. conditions are generally good. Soluble phosphorus and bacteria data both point to leaking sewers as an ongoing source of pollution. Indicator bacteria generally exceed state guidelines,
especially during wet weather. Sediments are chemically contaminated at multiple locations. This information is being used in a community-based creek revitalization plan now being developed. 

*Keywords: Biogeochemistry, Watersheds, Bioindicators.*

**GERRETSEN, J.**, Ontario Ministry of the Environment, 12th Floor, 135 St. Clair Ave. West, Toronto, ON, M4V 1P5.  **Introduction to Lake Simcoe Session.**

The Hon. John Gerretsen, Minister of the Environment, will introduce the session to highlight the work being done by the Province on the Lake Simcoe Protection Strategy.  *Keywords: Lake Simcoe, Watersheds, Ecosystem health.*

**GEWURTZ, S.B.**, ¹, HELM, P.,², CROZIER, P.W.,², REINER, E.,², HOWELL, E.T.,², and MARVIN, C.H.,³, ¹Brock University, 500 Glenridge Ave., St. Catharines, ON, L2S 3A1; ²Ontario Ministry of the Environment, 125 Resources Road, Toronto, ON, M9P 3V6; ³Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6.  **Spatial and Temporal Trends of Perfluorinated Compounds in Sediments and Surface Waters of the Great Lakes.**

Perfluorinated compounds (PFCs), primarily perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA), were measured in Great Lakes surficial sediment and water and in two Lake Ontario cores, as part of the Ontario Ministry of the Environment and Environment Canada monitoring programs. Both water and sediment PFC concentrations exhibited similar trends, whereby concentrations were highest in Lake Ontario, likely due to the influence of urban areas, and lowest in Lake Superior. Relatively elevated PFC concentrations were also detected in Georgian Bay, which were likely due to pulp and paper mill effluents. Sharp PFC concentration increases were found in the 3 most recent core slices of both Lake Ontario sediment cores and do not yet reflect PFOS usage reductions.  *Keywords: Perfluorinated compounds, Water quality, Sediments.*

**GILBERT, J.M.** and **LOCKE, B.**, Ontario Ministry of Natural Resources- Lake Erie Management Unit, 320 Milo Rd., Wheatley, ON, N0P 2P0.  **Ecological Assessments of Canadian Lake Erie Coastal Wetlands Identify Threats and Required Remediation Strategies.**

Assessments of the ecological health of coastal wetlands located within Rondeau Bay, along the Canadian shore of Lake Erie, were conducted in 2005 and 2006. Of the fifteen individual wetlands identified only one, existing within the boundaries of a provincial park, was considered to be relatively intact and healthy. The other 14 wetlands varied in size and diversity depending upon the degree of anthropogenic disturbance and surrounding landscape usage. All of the wetlands were colonized by the invasive alien species *Phragmites australis*. The presence of this plant has been identified as a major threat to biodiversity and the habitats required by a large number of existing species at risk. Other major threats to these systems, were poor nutrient management practices occurring throughout the small agriculturally based watershed, outdated septic systems within the residential communities, small buffers surrounding the wetlands, and the lack of connecting corridors. Based upon these and other identified
pressures a remediation strategy was developed to guide long-term management plans throughout the watershed toward targeted goals. In 2007, pilot projects were undertaken which focussed on the *Phragmites* and nutrient issues. These projects along with key components of the wetland assessments will be discussed. **Keywords:** Assessments, Ecosystem health, Coastal wetlands.

GILBERTSON, M., 46 James Street West, Guelph, ON, N1G 1E4, Canada. **Effects of Diversionary Reframing on the Selection of GLWQA Indicators.**

The negotiation and signing of the Great Lakes Water Quality Agreement was based on evidence of injury to health and property caused by pollution of the boundary waters. Attempted diversionary reframing to transform the purpose into restoration of Great Lakes ecosystem integrity has introduced far-reaching confusion into selection of priorities, management of programs and preparation of remedial action plans and lakewide management plans for critical pollutants. The reframing has introduced a long-term ambiguity into the Parties’ process of selecting indicators by which to assess progress in achieving the stated objective of maintaining and restoring water quality. The most effective processes for selection of GLWQA indicators have depended on statements of injury to organisms, including humans, caused by pollution of the boundary waters. Long-term monitoring of the incidence of injury and of the concentrations of the causal pollutants has provided reliable measures of Parties’ progress in maintaining and restoring water quality. The Parties’ review of the GLWQA should recognize the long-term utility of these indicator organisms by naming them in the Great Lakes Water Quality Agreement and by committing to continue their monitoring. **Keywords:** Indicators, Water quality, Pollutants.

GOGINENI, P., JANUSKA, B., MINNIEFIELD, C., and SIMOLIUNAS, S., Detroit River Remedial Action Council, 655 W. Warren Ave., Detroit, MI, 48201, USA. **The Mirage of Public Involvement.**

We have been involved as public members since the inception of the Detroit River Remedial Action Binational Public Council and Lake Erie Binational Forum. We were able to see the abolition of the former and the suspension of the latter. The lesson learned is that governments pay only lip service to meaningful public participation. The public has to be galvanized to demand meaningful public participation as outlined by the Binational Great Lakes Water Quality Agreement. **Keywords:** Great Lakes basin, Detroit River, Public participation.

GORMAN, O.T.¹, ROOK, B.J.², HANSEN, M.J.², and YULE, D.L.¹, ¹USGS Lake Superior Biological Station, 2800 Lake Shore Drive East, Ashland, WI, 54806; ²University of Wisconsin-Stevens Point, College of Natural Resources, Stevens Point, WI, 54481. **Population Trends in Lake Herring (*Coregonus artedi*) in the Apostle Islands Region of Lake Superior, 1974-2007.**

Lake herring underwent a robust recovery in Lake Superior in the late 1980s, which was well documented for the Apostle Islands region. We examined population trends from bottom trawl data collected over a 34-yr time series. From 1974 to 1984, abundance of lake herring was low and marked by recruitment failure. Recovery of lake herring commenced with the appearance of a very large 1984 year
class and followed by a series of large year classes in 1988, 1989, and 1990. Subsequent recruitment and growth of these cohorts led to record levels of density and biomass in the early to mid-1990s followed by a decline to lower levels in the late 1990s that have remained relatively stable to the present. After a 7-year hiatus, a moderate year class was produced in 1998 and another in 2003. Despite the presence of a large adult population since the mid-1990s, no large year classes have appeared. Relative population stability and intermittent recruitment since the late 1990s suggest a state of relative equilibrium. Factors likely contributing to population changes include: high recruitment variation, rainbow smelt (Osmerus mordax) suppression of recruitment prior to 1980, lake trout (Salvelinus namaycush) predation after 1984, and density-dependent moderation of recruitment by a large adult population after the mid-1990s.

Keywords: Fish populations, Recruitment, Lake Superior.

GRABUSKI, J.M.1, CAGAMPAN, S.J.1, STRUGER, J.1, and RONDEAU, B.2, 1Environment Canada, Burlington, ON, L7R 4A6; 2Environment Canada, Montreal, QC. Automated Solid Phase Extraction of Sulfonyle Ureas and Related Herbicides in Fortified Water and Natural Water Samples Using LC-ESI/MS/MS.

The identification and determination of sulfonyle ureas and other related herbicides have presented a challenge, both in specificity and sensitivity, when using conventional analytical techniques. Recent advances in solid phase extraction (SPE) technology combined with liquid chromatography tandem mass spectrometry (LC/MS/MS) have greatly improved this process. Hence, we developed a sensitive and robust analytical technique with supporting method detection limits (MDLs) using fortified Type I water. The applicability of the analytical method was then investigated on approximately 100 natural water samples from urban and agricultural watersheds in Ontario and Quebec, Canada. Nine sulfonyle ureas and six related herbicides in water were simultaneously extracted by an automated Autotrace SPE Workstation. Recoveries in the spiked Type I water samples were 96% or higher for all compounds except rimsulfuron, which was recovered at 60% (n=12). Instrument and MD limits ranged from 0.33 to 9.88 pg/μL and 0.7 to 22.0 ng/L, respectively. Maximum observed concentrations in natural water samples in 2007 were 858 ng/L for linuron and 873 ng/L for formesafen. Keywords: Pesticides, Watersheds.

GRETZ, M.R.1 and DOMOZYCH, D.S.2, 1Department of Biological Sciences, Michigan Technological University, Houghton, MI, 49931; 2Department of Biology, Skidmore College, Saratoga Springs, NY, 12866. It’s Only a Matter of Time: When Will the Diatom Didymosphenia geminata Become a Nuisance Alga in the Great Lakes Basin?

The pennate diatom Didymosphenia geminata has been historically noted as a low abundance species from alpine and boreal regions of the Northern Hemisphere. In recent years, streams in New Zealand, North America, Europe, and Asia have been disrupted by unprecedented blooms of this alga. Significant blooms have been reported from Victoria Island to Quebec in North America, and Biosecurity New Zealand is waging war on this invasive species which has significantly impacted streams of the south island. “Didymo” mats cover up to 100% of surfaces with thickness up to 30 cm, for reaches of several kilometers, greatly altering physical and biological conditions within streams and along lake
shorelines. The bulk of *D. geminata* biomass consists of extracellular stalks extruded through an apical pore field in the silica frustule. When cells grow and divide within a mat, the stalks bifurcate repeatedly, resulting in an aggregate “woven fabric” mat that traps algae, macroinvertebrates, detritus and other stream debris. These mats have been likened to raw sewage, complete with “toilet paper.” *D. geminata* stalks are primarily sulfated xylogalactan and we are investigating carbohydrate metabolism and glycan synthase activity to ascertain the causes of the dramatic upsurge in stalk production in recent years. 

*Keywords: Invasive species, Benthic flora, Algae.*

GUILDFORD, S.J.¹, DEPEW, D.C.², HOUBEN, A.², OZERSKY, T.², and HECKY, R.E.¹, ¹University of Minnesota Duluth, Duluth, MN, 55821; ²University of Waterloo, Waterloo, ON, N2L 3G1. **Seasonal and Spatial Trends in TP and Chlorophyll in Lake Simcoe: Impact of Dreissenids?**

Lake Simcoe is Ontario’s largest inland lake. Phosphorus removal from wastewater has significantly reduced earlier problems of eutrophication; however it is now experiencing the impact of exotic dreissenid mussels. Lake Simcoe has three distinctive basins. Cook’s Bay, historically very eutrophic, receives agricultural drainage from Holland Marsh and continues to support high macrophytes biomass. Kempenfelt Bay is an urbanized deep narrow basin. The remainder of the lake is a uniform open basin. In 2006 and 2007 we sampled the three basins including several shallow sites with extensive dreissenid coverage. Total phosphorus (TP) and chlorophyll *a* (Chl) were higher in Cook’s Bay than elsewhere in the lake. TP declined from May through August in all basins. Chl declined from May to July and then increased to a seasonal high at all locations in August. The shallow sites had significantly less chlorophyll that the other locations. Other measures related to particulate biomass (C, N, Si) including total suspended solids were all significantly lower at the shallow sites. Dissolved nutrients in contrast were relatively uniform around the lake. Our data suggest that in areas of Lake Simcoe impacted by dreissenids the expected coupling between nutrients and chlorophyll has been disrupted by dreissenid grazing. *Keywords: Phytoplankton, Phosphorus, Dreissena.*

GUNGOR, E.¹, ROBERTS, P.¹, MCCORMICK, M.J.², and SCHWAB, D.J.², ¹School of Civil Engineering, Georgia Institute of Technology, Atlanta, GA, 30332; ²NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 48105. **Dynamics of the Grand River Plume Entering Lake Michigan.**

Contaminants and fecal pollution from the Grand River may pose health risks to recreationers at the Grand Haven beaches and may major cause beach closing. This study focuses on the near field hydrodynamics of the Grand River plume as it enters lake Michigan. We develop a near field model to determine the fate and probability of beach contamination and to aid forecasting water quality along the beaches. Four intensive field experiments on the plume dynamics were carried out in the summers of 2006 and 2007. Artificial tracers (SF6 and Rhodamine WT) were added to the river upstream and profiles of plume properties were obtained by boats in the lake. In addition, currents, winds and waves were continuously measured and aerial photographs of the plume were obtained. It was found that the river plume forms a buoyant surface jet. In this paper, the field data are discussed and experiments are proposed using three-dimensional laser-induced fluorescence (3DLIF) to investigate the characteristics of
the river plume and its mixing and transport mechanisms. The results of this research will improve simulations of water quality in nearshore areas and aid in predicting beach closures. **Keywords: Human health, Hydrodynamics, Mathematical models.**


The round goby (*Neogobius melanostomus*) is an invasive fish that is rapidly expanding its range in the Great Lakes watershed. The species’ life history and mode of range expansion is poorly understood, and has not been quantitatively investigated in newly invaded environments. Knowledge of life history traits is necessary to better understand how the round goby adapts and manages to spread rapidly. Round gobies were collected in the center and edge of their distribution in the Trent River over the 2006 and 2007 breeding seasons. The samples were then used to compare reproductive energy allocation between established and expanding aggregates of the population. Preliminary results indicate that round gobies on the edge of expansion allocate more energy to reproduction than those collected from the site of introduction. These results suggest that a high level of phenotypic plasticity in life history traits may be an important biological trait in invasive fishes. While it is unlikely that the round goby can be eradicated from North American sites where it is already established, its spread may be slowed by focusing removal efforts on segments of the population at the edges of expansion where the highest levels of reproductive allocation are occurring. **Keywords: Round goby, Invasive species, Life history studies.**

HAGAR, J., REDISKE, R.R., O’KEEFE, J.P., and HONG, Y.E., Annis Water Resources Institute, Grand Valley State University, Muskegon, MI, 49441. **Detection and Quantification of Cyanobacteria and Microcystin in Recreational Waters of Two West Michigan Lakes: Muskegon Lake and Bear Lake Using Three Different Methodologies.**

Microcystins are among the most frequently occurring and widely distributed cyanobacterial toxins found in freshwater lakes. They form a family of hepatotoxins that can be potent protein phosphatase inhibitors and have been implicated in human and animal poisonings. In the summer of 2006, microcystin concentrations were investigated in Bear Lake and Muskegon Lake. The performance of three analytical techniques: ELISA, PPIA, and HPLC/MS also was evaluated. In Bear Lake, mean microcystin concentrations were 1.74 μgL⁻¹, 3.06 μgL⁻¹, 1.66 μgL⁻¹ when measured by ELISA, PPIA, and HPLC/MS, respectively. PPIA microcystin activity was significantly higher than ELISA microcystin LR equivalent concentrations (p<0.001) and HPLC/MS-Total microcystin concentration (p<0.001). ELISA results were moderately significantly higher than HPLC/MS-Total concentrations (p=0.043). In Muskegon Lake, mean microcystin concentrations were 0.42 μgL⁻¹, 0.55 μgL⁻¹, 0.52 μgL⁻¹ when measured by ELISA, PPIA, and HPLC/MS, respectively. PPIA microcystin activities were significantly higher than ELISA microcystin LR equivalent concentrations (p<0.001) but not significantly different than HPLC/MS-Total microcystins concentrations (p=0.265). ELISA results were significantly lower than HPLC/MS-Total microcystin concentrations(p=0.002).
HALL, E.\textsuperscript{1}, BOEGMAN, L.\textsuperscript{1}, YERUBANDI, Y.\textsuperscript{2}, and PATURI, S.\textsuperscript{1}, \textsuperscript{1}Department of Civil Engineering, Queen's University, Kingston, ON, K7L3N6; \textsuperscript{2}National Water Research Institute, Environment Canada, Burlington, ON, L7R 4A6. \textbf{Modeling Lake Ontario Hydrodynamics: Performance of Basin-scale and Nearshore Simulations.}

Reynolds averaged hydrodynamic computational models are now capable of simulating the offshore three-dimensional circulation in the Great Lakes on coarse grids (km scale) over seasonal timescales. Their performance in nearshore regions has not been well documented, yet these basin-scale models are increasingly being used to specify the open boundary forcing condition for high-resolution nearshore models. In this study, we test the ability of the three-dimensional Estuary and Lake Computer Model (ELCOM) to simulate Lake Ontario hydrodynamics at both nearshore and offshore field stations. The model accurately reproduces the offshore thermal structure. To correctly simulate nearshore water levels, the Niagara and St. Lawrence River flows are not sufficient; all major tributary flows must be included. Nearshore current profiles are not well modeled. Preliminary results from a high-resolution nearshore model (100 m scale) of the eastern Lake Ontario and upper St. Lawrence River hydrodynamics will be presented with particular emphasis on the sensitivity of this model to the open-lake boundary condition. \textit{Keywords: Hydrodynamic model, Lake Ontario, Model testing.}

HAN, H. and ALLAN, D., University of Michigan School of Natural Resources and Environment, Dana Building, 440 Church St., Ann Arbor, MI, 48109-1041, US. \textbf{Phosphorus Loading to Lake Erie Watersheds: A Mass Balance Approach.}

Mass balance estimates of nutrient inputs to and exports from entire watersheds provide insight into nutrient loss or sequestration and the influence of agricultural and urban land use. We quantified mass balance of phosphorus for the entire 25 Lake Erie watersheds in the United States and Canada for 2002, and extended historical P budgeting only for the watersheds located in the United States from 1987 to 2002 at 5 yr intervals. We 1) quantified P inputs to all watersheds from atmospheric deposition, fertilizer use, and net import of P in food and feed, 2) analyzed the relationship between trends in total net P inputs and land use; and 3) determined P input-export relationships. The magnitude of P inputs to each watershed and importance of the relative P inputs varies greatly over space but not over the 15-year time interval. P inputs to watersheds are well correlated with land use composition, showing a positive correlation with land in agriculture and a negative correlation with land in forest. On average, over all watersheds, fertilizer use is the largest single P input, followed by net import of P in food and feed, and atmospheric P deposition. \textit{Keywords: Phosphorus, Mass balance, Lake Erie.}

HANSEN, D.L.\textsuperscript{1}, ISHII, S.\textsuperscript{2}, SADOWSKY, M.J.\textsuperscript{2}, and HICKS, R.E.\textsuperscript{1}, \textsuperscript{1}Department of Biology, University of Minnesota Duluth, Duluth, MN, 55812; \textsuperscript{2}Department of Soil, Water & Climate, University of Minnesota, St. Paul, MN, 55108. \textbf{Waterfowl Abundance is Not a Reliable Predictor of the Dominant Avian Source or Levels of Fecal Indicator Bacteria at Lake Superior Beaches.}
The HFERP DNA fingerprinting technique was used to identify potential sources of *E. coli* at two beaches in the Duluth-Superior Harbor during May, July, and September 2006. Waterfowl were the largest source of *E. coli* that could be identified in water (55-100%), sand (59-100%), and sediment (92-100%) at both beaches throughout the study. Although ring-billed gulls were more abundant in this harbor, Canada geese were usually the dominant source of waterfowl *E. coli* found at these beaches. The percentage of *E. coli* identified as coming from treated wastewater was always less than the percentage of *E. coli* originating from waterfowl. At both beaches, the percentage of *E. coli* found in water and contributed by treated wastewater was higher in May compared to July and September. The larger proportion of wastewater-derived *E. coli* seen in May was probably more reflective of the smaller contribution of *E. coli* from geese when they were less abundant rather than an absolute increase in *E. coli* from treated wastewater. Microbial source analysis and bird census data both indicated that waterfowl were a major source of *E. coli* at these beaches. Our data, however, also indicate it is risky to assume that the most abundant waterfowl species present in waterways will also be the largest source of avian-derived *E. coli* at beaches. **Keywords:** Bioindicators, Water quality, Microbiological studies.

**HANSEN, G.J.A.** and **JONES, M.L.**, Michigan State University, Department of Fisheries and Wildlife and Quantitative Fisheries Center, 13 Natural Resources Building, East Lansing, MI, 48824. A **Comparison of Two Methods of Larval Sea Lamprey (Petromyzon marinus) Assessment in the Great Lakes: How Much Information Is Needed to Effectively Rank Streams for Treatment?**

Sea lampreys (*Petromyzon marinus*) are invasive to the Great Lakes and are managed largely through the use of lampricides that target the non-parasitic, stream-dwelling larval stage. A resource-intensive larval assessment process (Quantitative Assessment Sampling, QAS) is currently used to determine which streams to treat in a given year. We developed an alternative assessment procedure known as Rapid Assessment (RA) that required fewer resources to carry out, and assumed that any savings resulting from the use of RA would be used to treat additional streams with lampricide. We implemented both assessment methods basin wide from 2005-2007 and compared the costs (assessment expenditures) and benefits (sea lampreys killed) of each approach. Population estimates generated from these assessments as well as mark-recapture studies indicate that basing stream treatment decisions on RA results in at least as many, if not more, sea lampreys killed than basing decisions on QAS. RA does not appear to perform as well as QAS when assessment savings are not used to treat additional streams. These results have led to a decision by the Great Lakes Fishery Commission to change larval assessment protocols to more cost-effectively manage sea lampreys in the Great Lakes. **Keywords:** Assessments, Sea lamprey, Comparison studies, Decision making.


Viruses are ubiquitous in aquatic ecosystems and especially important in nutrient cycling through lysis of phytoplankton and bacteria. The role of viral lysis in carbon cycling is well established in marine microbial food webs, but less is known for other elements or for freshwaters. We examined the viral
community in Lake Michigan and assessed its contribution to cycling of the limiting nutrient phosphorus. Surface water samples from nearshore (<100 m and <10 m depth) and offshore (>2 km and >10 m depth) were characterized using epifluorescence and transmission electron microscopy (TEM). 48.6% of viruses had icosahedral head and tails, suggesting that phages are numerically dominant. Using tangential flow filtration and spot plaque assays, a virus that lysed cultures of Pseudomonas sp. (cultured from Lake Michigan) was isolated from nearshore surface water and purified. To examine the significance of viruses to P cycling, we are currently comparing dissolved and particulate P fractions measured in Pseudomonas sp. cultures with and without viral lysis. Quantifying the potential for P release due to viral lysis will help determine the significance of viruses in the Lake Michigan P cycle. Keywords: Microbiological studies, Viruses, Phosphorus, Lake Michigan.


DNA sequencing offers new tools to discern and distinguish among cryptic taxa. Our study tests the systematic identity and genetic divergence distinguishing members of the greenside darter Etheostoma blennioides complex, including cryptic taxa and subspecies, in areas of sympatry and allopatry. DNA sequences (1,497 bp) from the mtDNA cytochrome b gene and control region and the nuclear S7 intron 1 are compared from 294 individuals across 18 locations in the lower Great Lakes and Ohio River watersheds. MtDNA results define four taxa; E. b. blennioides, E. b. newmanii, and E. b. pholidotum, and a new clade in the Meramec River, which are distinguished by pronounced divergences (θST = 0.92-0.97; p-distance = 0.025-0.039), many synapomorphies, and reciprocal monophyly. The nuclear sequences clearly resolve the Meramec River clade. The four genetic taxa of the greenside darter complex likely diverged during the early Pleistocene Epoch based on a molecular clock calibration for the cytochrome b gene in darters of 2% per million years. The four cryptic taxa thus should be evaluated further for potential elevation to species level. Keywords: Biodiversity, Fish populations, Genetics.

HEBERT, C.E.1, WESELOH, D.V.2, and GAUTHIER, L.1, 1Environment Canada, National Wildlife Research Centre, Ottawa, ON, K1A 0H3; 2Environment Canada, Canadian Wildlife Service, Downsview, ON, M3H 5T4. Ecological Tracers Reveal Pathways of Contaminant Transfer to Avian Predators.

Food web structure regulates the flow of energy, nutrients, and persistent organic contaminants (POPs) to top predators. Pathways of contaminant transfer can be understood by measuring ecological tracers in predator tissues. Ecological tracers are stable chemical or biochemical compounds, such as stable nitrogen isotopes and fatty acids. In this study, we use these tracers to track contaminant flow to herring gulls (Larus argentatus) breeding on the Great Lakes. Pathways of exposure to both legacy contaminants (e.g., Hg, PCBs) and emerging contaminants (i.e., PBDEs) are assessed. Analysis of individual eggs within particular years indicated that birds consuming more aquatic prey occupied higher trophic positions and exhibited greater levels of Hg and legacy POPs. However, pathways of PBDE exposure were different. Greatest PBDE levels appeared to be associated with birds utilizing prey associated with terrestrial food webs. These birds had the highest PBDE levels yet reported anywhere in
the world (e.g., sum PBDE 12.5 ppm wet wt., 143 ppm lipid wt.). Ecological tracer "fingerprints" in wildlife can provide insights into routes of transfer of both legacy and emerging contaminants leading to an improved understanding of contaminant sources. **Keywords:** Food chains, Environmental contaminants, Polybrominated diphenyl ethers.

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

Aquatic protected areas (APAs) have become a popular tool for fisheries management and conservation. APAs protect fish or habitats from exploitation and perturbations, potentially increasing the resilience of natural populations, enhancing fisheries and facilitating the persistence of native populations. The purpose of this project is to understand the role that APAs have and should play in the management and conservation of Great Lakes fish populations. An inventory of past and present Great Lakes APAs (GL-APAs) has illustrated various reasons and methods for APA creation. GL-APAs have occasionally been created as fisheries management tools, however, the majority of sites have arisen indirectly through the creation of shoreline parks or de facto protected areas that occur when human activities are locally restricted because of hazardous facilities or military installations and activities. Currently, all known evaluations of the effectiveness of GL-APAs are being summarized to determine their successes and failures. A standardized evaluation of the effectiveness of GL-APAs will be undertaken and a GAP analysis will be used to determine fish species and habitats that are not protected by current APAs; the combined results will be used to provide recommendations for future APAs and identify research priorities. **Keywords:** Great Lakes basin, Refugia, Fish.

HELM, P.1, BHAVSAR, S.1, HAYTON, A.1, REINER, E.1, GEWURTZ, S.B.1, FURDUI, V.1, ISMAIL, N.3, PLESKACH, K.3, CROZIER, P.W.1, MABURY, S.4, MARVIN, C.H.5, and TOMY, G.3. 1Ontario Ministry of the Environment, Toronto, ON; 2Fisheries & Oceans Canada, Burlington, ON; 3Fisheries & Oceans Canada, Winnipeg, MB; 4University of Toronto, Toronto, ON; 5Environment Canada, Burlington, ON. **Concentration Trends of Past- and Current-use POPs in Lake Trout from the Great Lakes.**

Assessment of long-term concentration trends in sport fish such as lake trout is important for evaluating progress toward the goal of reducing harmful pollutants entering the Great Lakes, achieving fish concentrations that are free of consumption restrictions, and prioritizing management actions to prevent accumulation of current-use persistent organic pollutants (POPs) to levels of concern. Here we summarize recent observations in polychlorinated biphenyl (PCB) concentration trends Great Lakes sport fish through the Ontario Ministry of the Environment’s sport fish monitoring program, and concentration trends of several past- and current-use POPs in archived Lake Ontario lake trout from Fisheries & Oceans Canada/Environment Canada monitoring. PCB concentrations continue to decline in Lakes Huron and Ontario, while recent trends in Lake Superior remain unchanged and Lake Erie concentrations are again increasing. In Lake Ontario lake trout, concentrations of Dechlorane Plus and polychlorinated naphthalenes declined similarly to PCBs and polychlorinated dioxins and furans since the late 1970s. However, brominated flame retardants such as the polybrominated diphenyl ethers (PBDEs), and
fluorinated chemicals such as the perfluorinated sulfonates and carboxylates, have increased or exhibited more variable trends over this time. **Keywords: PCBs, Lake trout, PBDEs.**

HENSHEL, D.S.¹ and DA SILVA, A.F.², ¹Indiana University, 1315 E 10th St, #340, Bloomington, IN, 47405; ²Northern Illinois University, Department of Political Science, Dekalb, IL, 60115. **Using Landscape Scale Modeling as a Tool to Assess Potential Health Indicators.**

We have been working to develop new tools that can be used to screen for potential human health indicators of the population level impacts of exposures to environmental stressors. These techniques enable investigators to screen large areas for potential public health impacts that are linked to exposure to environmental contaminants. Using available databases of health effects and indicators of potential exposure to environmental contaminants, we have used a number of statistical methods and other modeling tools to identify linkages between public health parameters and indices of environmental exposure. We shall demonstrate a number of the most useful methods by presenting several case studies drawn from Indiana and the Great Lakes. We shall clarify how these tools can be most useful in indicating needs for more detailed studies, and identify specific shortcomings in both the techniques and the problems associated with data availability. Finally we shall present a series of recommendations for improving both environmental monitoring and public health databases to make them more useful for such landscape scale screening evaluations. **Keywords: Bioindicators, Endocrine disruption, Environmental health.**

HENSHEL, D.S.¹ and SPARKS, D.W.², ¹Indiana University, 1315 E 10th St. #340, Bloomington, IN, 47401; ²U.S. Fish and Wildlife Service, 620 S. Walker St., Bloomington, IN, 47403. **Developing Avian Delisting Criteria for the Great Lakes AOCs.**

At this time there are no specific delisting criteria developed for insectivorous avian wildlife in any RAP. Within the USFWS and the CWS, swallows have been identified as critical indicator species for the insectivorous avian portion of affected food webs and ecosystems. We have been working with tree swallow populations in the southern part of Indiana and barn swallow populations from the Great Lakes region to assess and develop a more complete set of avian health indicators in order to identify specific delisting criteria for insectivorous avian wildlife for the GCR RAP. Most contaminant-related effects that had been previously quantified for swallows have included standard ecological monitoring parameters such as productivity and behavior. Analysis of the data (standardized in the tree swallow population, and quantified in the barn swallow population) indicates that whereas these parameters may be affected in a contaminated population, developmental deformities and changes in growth parameters in both timed embryos and nestlings provide much more sensitive indicators of individual effects, and are much more likely to indicate whether the animal is likely to survive and be able to reproduce in the long term. **Keywords: Lake Michigan, Bioindicators, PCBs.**
HENSLER, S.R., JUDE, D.J., and OMAIR, M., University of Michigan - School of Natural Resources and Environment, 440 Church St., Ann Arbor, MI, 48109. Documentation of the Incidences of Herniations in Great Lakes Copepods.

Herniations in Great Lakes zooplankton were first documented in 1999, but detailed information about spatial and temporal incidence rates among lakes and species has not yet been presented. Such information may prove useful to guide future research efforts and help determine potential causes and implications of this phenomenon. Zooplankton used for this analysis were collected at offshore sites during April and August 2007 as part of the U. S. EPA – GLNPO Biological Monitoring Program on the Great Lakes. During standard zooplankton identification counts, herniation incidences were recorded for both immature and adult copepods. Adult incidence rates were recorded by sex. Analyses to date indicate that 8.5%, 3%, 1%, and <1% of all copepods are affected in Lakes Michigan, Huron, Ontario, and Superior, respectively. Males are 5.7 times more likely to be affected than females. Copepods in the genus Diaptomus are most susceptible, with incidence rates as high as 51% for some species in individual samples. Since herniation incidence rates vary among lakes, species, and sexes, they may be caused by environmental factors (e.g., toxic substances, endocrine disrupting compounds) and exacerbated by the physiology or ecology of certain species. Perhaps, herniations could prove useful as biological indicators of ecosystem health. Keywords: Great Lakes basin, Biomonitoring, Zooplankton.

HODGINS, B., TRYON, K., and LUSH, D.L., Town of Ajax, 65 Harwood Ave., Ajax, ON, L1S 2H9; P.O. Box 70, Palgrave, ON, L7E 3S9. Challenges of Developing Adaptive Environmental Regulatory Policy.

The Lake Ontario basin is bearing the brunt of factors driving changes in water quality, quantity and ecosystem structure. It is government policy to rapidly increase the population of the basin over the next few decades. This population increase will further urbanize the Basin, resulting in more intensive land use, necessitating massive investments in municipal infrastructure. Climate change will likely result in changes in precipitation, flows and water levels changing hydraulic resident times and flushing rates. Current policies and regulations based on observed past ecosystem response are unlikely to be appropriate for future conditions. Future policies and associated legislation and regulations will have to recognize this uncertainty. With this will come an associate short term “societal cost,” but paying this short-term cost will almost certainly be less expensive in dollar costs, if not political cost, than the costs our children will have to pay to remediate the problems caused by exceedence of the long term carrying capacity of the Basin. Keywords: Decision making, Economic impact, Phosphorus.

HOLLENHORST, T.P., JOHNSON, L.B., CIBOROWSKI, J.J.H., HOST, G.E., and DANZ, N.P., Center for Water and the Environment, Natural Resources Research Institute, University of Minnesota, 5013 Miller Trunk Highway, Duluth, MN, 55811; Department of Biological Sciences, University of Windsor, Windsor, ON, N9B 3P4. An Integrated, Watershed Based, Anthropogenic Stressor Gradient for the Great Lakes.
Watersheds represent spatially explicit areas within which terrestrial stressors can be quantified and linked to measures of aquatic ecosystem condition. Using elevation data, we delineated a set of nearly 6,000 high resolution coastal watersheds covering the entire Great Lakes basin. These watersheds were ordered (numbered sequentially), along the coastline to allow agglomeration into larger basins for specific regions of interest (e.g., stretches of high energy shoreline or embayments). Using these watersheds, we summarized U.S. and Canadian maps of land cover, population density, road density, agricultural land use and point sources to characterize various types of anthropogenic stress likely to affect each watershed. These measures were transformed, normalized and standardized, converting each stressor metric to a common scale. To incorporate information from the different stressors we combined the stressor metrics in three different ways: 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 us to make an “a priori” identification of the least disturbed (reference) and most disturbed areas.

Keywords: Great Lakes basin, Indicators, Watersheds.

HOLSEN, T.M., CRIMMINS, B., and MAYER, M., Clarkson University, Potsdam, NY, 13699, USA.

Great Lakes Fish Monitoring Program: Mercury.

The Great Lakes Fish Monitoring Program (GLFMP) began in 1980 as a cooperative effort to track the trends of selected organic contaminants in the Great Lakes ecosystem. Currently, two facets of this program assess the fishery contaminant burden (Open Lakes Trend Monitoring Program) and human exposure (Game Fish Fillet Monitoring Program) using whole fish composites and game fish fillets, respectively. In this paper mercury concentrations obtained using a direct analysis method (thermal decomposition technique) in open water whole fish samples will be presented. In addition a direct comparison between this relatively new technique and more traditional digestions/analysis techniques will be presented. Keywords: Mercury, Fish toxins, Chemical analysis.

HOOD, J.L.A. and TAYLOR, W.D., University of Waterloo, 200 University Ave. West, Waterloo, ON, N2L 3G1. Significance of Riverine Macrophytes as a Sink for Watershed Derived Phosphorus Loading to Lake Erie.

The Grand River is the largest Canadian tributary to Lake Erie, and a significant source of dissolved and particulate phosphorus. During the summer, when loading is low but important to nearshore eutrophication, a significant portion of P is retained within watershed sediments and biota and not exported to the lake. Submersed macrophytes are a conspicuous part of the riverine community, particularly in the middle reaches of rivers affected by sewage and agricultural run off. Seasonal development of high macrophyte biomass is common and is thought to contribute to hypoxia through night-time respiration. However, riverine macrophytes may represent a large temporary sink for P destined for lake Erie. The retained P eventually enters the lake at the end of the growing season, seasonally shifting the load and possibly aiding in the reduction of summer nearshore algal blooms. Here we present the results of a multiple year study of riverine macrophyte biomass and tissue P content at the reach scale in the Grand River watershed. We make estimates of the importance of macrophytes as a P
sink for the entire watershed by extrapolation. We compare the macrophyte P pool with dissolved and particulate P exported seasonally and annually to show that macrophytes can represent a significant sink for watershed derived bioavailable phosphorus. Keywords: Phosphorus, Macrophytes, Watersheds.

HÖÖK, T.O.1, BELETSKY, D.1, MASON, D.M.2, RUTHERFORD, E.S.3, and SCHWAB, D.J.2, 1U. Michigan, CILER, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105; 2NOAA, Great Lakes Environmental Research Laboratory, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105; 3U. Michigan, School of Natural Resources and Environment, Institute for Fisheries Research, Ann Arbor, MI, 48109.

A Linked Hydrodynamic and Individual-based Model to Simulate Alewife Recruitment in Lake Michigan.

Recent studies suggest that alewife (Alosa pseudoharengus) year-class strength in Lake Michigan is influenced by summer temperatures and salmonine predation. As lake currents have the potential to rapidly transport fish larvae to both favorable and unfavorable nursery habitats, we hypothesize that variable lake currents also play a role in determining alewife recruitment success. To consider how annual variation in lake currents and temperatures may jointly influence year-class strength, we linked a 3-D particle transport model with an individual-based model of early life alewife growth and survival. Transport processes influence the foraging success of larvae by determining individuals’ thermal and foraging environments, thereby affecting growth rate and the length of time individuals are susceptible to size-selective predators. Results suggest that the extent to which variable lake currents influence alewife year-class strength is dependent on the spatial distributions of alewife predators and prey. When foraging opportunities and predation pressure do not vary spatially, simulations suggest that while local recruitment success (i.e., survival of individuals emanating from a small region of the lake) can be highly variable, inter-annual variation in lake-wide year-class strength is low. Keywords: Alewife, Recruitment, Water currents.

HORNBUCKLE, K.C. and MARTINEZ, A., 4105 Seamans Center for the Engineering Arts and Sciences, Iowa City, IA, 52242. PCBs in Surficial Sediments in East Chicago, Indiana.

East Chicago is a heavily industrialized urban community on the southern shore of Lake Michigan. Penetrating the city center is the Indiana Harbor and Shipping Canal, an Area of Concern designated by the International Joint Commission due to contamination by many environmental pollutants including polychlorinated biphenyls (PCBs). PCBs are known to contaminate the harbor and canal, although there is little published data describing the spatial extent and concentration magnitude. Therefore, we have conducted a sampling expedition designed to allow a multimedia comparison of PCB concentrations and fluxes in the harbor system. We collected surficial sediment, water, and air samples from the harbor and connected canal. The surficial sediment samples were extracted using accelerated solvent extraction. The extracts were analyzed for all 209 PCB congeners by tandem mass spectrometry. Preliminary results, which are presented in this paper, indicate an enrichment of PCBs in the canal in comparison to the harbor, as well as the open lake. Concentrations of total PCB in the samples range from 50 to 27,000 ng/g (dry weight). Average % recovery for surrogate standard – PCB 166 – was 86% and
standard deviation of 16%, with a range from 58 to 114%. Keywords: Spatial analysis, Sediment quality, PCBs.

HOUBEN, A.¹, DEPEW, D.¹, OZERSKY, T.¹, GUILDFORD, S.J.², and HECKY, R.E.², ¹200 University Ave. W., Waterloo, ON, N2L3G1; ²1035 Kirby Dr., Duluth, MN, 55812. Benthic Algal Nutrient Dynamics within Lake Simcoe.

Surveys of Lake Simcoe were performed in 2006-2007 to observe the progression of the nearshore phosphorus shunt. Dreissenid mussels had established themselves on all hard substrates and the benthic nuisance alga, *Cladophora glomerata*, was expected to follow. However, during the study we paradoxically observed extremely low presence of *C. glomerata* while measuring higher concentrations of total phosphorus (10.0 μg*L⁻¹*), soluble reactive phosphorus (1.4 μg*L⁻¹*), and *C. glomerata* internal phosphorus concentrations (2.1 μg P*mg dw⁻¹*), with respect to Lakes Erie and Ontario. Similar shorelines within these two Great Lakes were measured to have SRP concentrations as low as detection limit (< 0.35 μg*L⁻¹*) and *C. glomerata* internal P concentrations below P-limitation (< 1.6 μg P*mg dw⁻¹*) throughout the period of peak biomass while virtually all sampling stations had *C. glomerata* presence. This talk will analyze the deeper effects of Lake Simcoe physical dynamics and the potential for nitrogen limitation in relation to the nearshore phosphorus shunt in hopes to determine why *C. glomerata* has not exploited this system. Keywords: *Cladophora*, Lake Simcoe, Nutrients.

HOWELL, E.T., 125 Resources Road, Toronto, ON, M9P 3V6. Influence of a Small Agriculturally-dominated Watershed on the Nearshore of SE Lake Huron.

Eighteen Mile River shares features with many shoreline tributaries to SE Lake Huron. Much of the drainage area is deforested and in agricultural use. The shoreline is developed as residential properties with an abundance of beaches. Concurrent monitoring of Eighteen Mile River with surveys of nearshore water quality was used to examine effects of the river on the nearshore. Nitrate levels in the nearshore were elevated at times of seasonally high river discharge and strongly correlated with conductivity and depth. Conductivity and nitrate were used as indicators of runoff to track the spatial extent of shoreline inputs on nearshore water quality which ranged from broad to non-detectable. Levels of the fecal pollution indicator *E. coli* in the nearshore did not consistently covary with indicators of runoff. The pronounced decline in nitrate concentrations during the drier summer months was not evident in *E. coli* counts. Despite wide variations in total phosphorus levels near the shoreline, oligotrophic conditions prevailed as inferred from chronically low levels of chlorophyll *a*. At times, erosion contributed to high levels of suspended solids in the nearshore and to the variability in total phosphorus. The diverse conditions observed over 19 months highlight the need for integrative monitoring strategies. Keywords: Lake Huron, Coastal ecosystems, Tributaries.

HOYLE, J.A.¹, CHRISTIE, G.C.¹, BOWLBY, J.N.¹, MORRISON, B.J.², and WRIGHT, M.E.², ¹Ontario Ministry of Natural Resources, 41 Hatchery Lane, Picton, ON, K0K 2T0; ²Ontario Ministry of Natural
Response of Freshwater Drum to a Disease Outbreak in Lake Ontario.

Freshwater drum (*Aplodinotus grunniens*) is an abundant, large-bodied, native species in the nearshore waters of eastern Lake Ontario. The drum population in this region endured an extraordinary mortality event in the spring of 2005. Samples of dying and dead drum were determined to be infected with Viral Hemorrhagic Septicemia (VHS)—the first identified case of this internationally reportable disease in Canadian fresh water. The large number of drum observed dying and dead along with concern about the spread VHS to other species and water-bodies generated significant public and government concern. We assess drum relative abundance, before and after the die-off, using gillnet, trapnet and trawling surveys designed to monitor the fish community, and incidental catch rates in a recreational walleye fishery. The abundance of drum age-1 yr and older did not decline after the die-off. Either the number of drum that died was insignificant relative to the total population or deaths caused by the disease replaced deaths that would have occurred due to other causes. We suggest that the rapid and visual accumulation of dead fish may have caused an initial over-estimation of the die-off’s effect on the drum population. Paradoxically, there was a significant increase in young-of-year drum abundance after the disease outbreak. Keywords: Fish diseases, Freshwater drum, Lake Ontario.

Prevalence and Distribution of Atmospheric Polychlorinated Biphenyls in Chicago.

The magnitude, spatial extent and variation of PCBs in urban air were investigated in the cities of Chicago, Illinois and East Chicago, Indiana. The concentrations of PCBs in air were measured at two schools and the former Energy Cooperative Incorporation (ECI) site in East Chicago and 44 schools in Chicago. For the Chicago sites, a novel sampling strategy was developed to facilitate collection of air samples throughout the city. The device consists of a high-volume air sampler (Hi-Vol, Tisch Environmental) mounted on a movable frame that attaches to a recreational vehicle. We have installed two of these devices on health clinic vans operated by Mobile C.A.R.E. Foundation of Chicago. An air sample is collected when each van serves one location, typically an elementary school, each school day. The air samples consist of a quartz fiber filter to collect particles and an XAD resin to collect PCB in the gas phase. All samples were measured for a suite of 209 congeners by GC/MS/MS. The average amount of PCBs in field blanks and solvent blanks were both less than 5% of the total mass in the sample. The recovery of PCB 166 surrogate standard was 67 ± 19%. The preliminary results from the first season of a four-year project showed that the concentration of atmospheric PCBs in Chicago ranged from 50 to 1,600 pg/m³ in the winter. Keywords: PCBs, Air, Environmental contaminants.

From Toxic Soup to Sleeping with the Enemy: How a Stakeholder Approach Helped Hamilton Harbour Become a Model for Community Engagement.
Hamilton Harbour was the most polluted Area of Concern on the Canadian side of the Great Lakes. Its industrial legacy, including steel-making and war-time coal gasification plants, left behind a nasty collection of coal tar that ranks second only to the Sydney Tar Ponds. This nasty toxic soup was matched by nasty toxic mistrust among industry, citizens, government, and yachters who accused each other of elitism, misinformation, greed and other unprintable epithets. What happened? Some wise people opted for a community stakeholder or community engagement model as a foundation for progress. This approach has worked with environment-related issues across North America, from polluted rivers to disputes about ski hill expansion. Comparative reference will be made to such seemingly unrelated disputes. How did the Hamilton Harbour Remedial Action Plan (HHRAP) work from the perspective of this model? How did the community engage … and why? What lessons can be learned? What can community groups do effectively? What now? Speaker Jim Hudson is Executive Director of the Bay Area Restoration Council, the community group at the center of efforts to restore Hamilton Harbour. He has studied environmental disputes across North America. Keywords: Lake Ontario, Cleanup, Non-governmental organizations.

HUNTER, T.S.¹, HE, C.², CROLEY, T.E.¹, and DEMARCHI, C.³, ¹NOAA Great Lakes Environmental Research Laboratory, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105-1593; ²Department of Geography, Western Michigan University, 3234 Wood Hall, Kalamazoo, MI, 49008-5424; ³School of Natural Resources and Environment, University of Michigan, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105-1593. Forecasting Grand River (Michigan) Discharge and Pollution Loads.

As part of the Center of Excellence for Great Lakes and Human Health (CEGLHH) suite of models for forecasting water quality, beach closures, and the occurrence of harmful algal blooms, we are developing a short-term forecasting system of discharge and pollutant loads for major watersheds of Lake Michigan. Discharge is forecasted by feeding 1-2 day weather forecast from the National Weather Service to GLERL’s Distributed Large Basin Runoff Model (DLBRM). A dual approach is taken for forecasting pollutant loads: initially we will predict water quality parameters from discharge and meteorological forecasts by using locally calibrated regression models. In parallel, we are introducing transport models into the DLBRM for the most important pollutants. Together with a detailed mapping of point and nonpoint pollution sources in the watershed, these models will eventually allow better short-term forecasts of pollutant loads and the evaluation of land use changes and pollution prevention policies on water quality. An application of the forecasting system to the Grand River watershed in Michigan is shown. Keywords: Beach closure forecasting, Watershed hydrology, Water quality.

HURLEY, T. and CHOW-FRASER, P., McMaster University, Dept. of Biology, 1280 Main St. West, Hamilton, ON, L8S 4K1. Fish Community Changes Associated with Water-level Decline in Wetlands of Severn Sound, Georgian Bay.

Near-shore fish habitat is critically important to many Great Lakes fishes and currently faces threats from anthropogenic disturbance and water level fluctuations. In Severn Sound (Georgian Bay), there has been substantial shoreline alteration and a drop in water level of 80 cm over the past 25 years. We investigated how muskellunge nursery habitat have changed between 1981 and 2007, based on a
survey of fish and plant communities at 10 sites in Severn Sound. The sampling protocol used in the 1981 survey were duplicated in 2007. Despite the shoreline modifications, there has been no significant change in water-quality conditions between the two sampling years. However, deep-water emergent species have decreased in prominence, while early successional and shoreline species have increased. More pronounced changes were seen in the fish community. Young-of-year muskellunge and black crappie, both present in 1981, were completely absent in 2007. Also, yellow perch and largemouth bass represented a significantly lower proportion of the total catch in 2007 than in 1981, with a concomitant increase in the proportion of small minnow species. GIS spatial analysis revealed that a considerable amount of fish habitat has been lost over the 26 years, and this is most likely the result of the large drop in water levels. 

**Keywords:** Wetlands, Lake Huron, Fish.

JACKSON, J.A., 17 Major St., Kitchener, ON, N2H 4R1. **The Experience of Ontario Activists in the RAP Process.**

In this paper, we explore the experience of citizens in Ontario in participating in the Remedial Action Planning process over the past twenty years. The report explores the roles of public advisory councils and the barriers that PACs encounter when trying to achieve these goals. Ways for overcoming these barriers are explored. This survey of RAP experience was prepared through the Ontario Public Advisory Council, which is made up of a representative from each PAC in Ontario. 

**Keywords:** Public participation, Areas of concern cleanup, Environmental policy.

JAMES, L.A.H., ARNOTT, S.E., and CASSELMAN, J.M., Department of Biology, Queen's University, Kingston, ON, K7L 3N6. **Effect of the Invasive Predator, Bythotrephes longimanus, on Growth of Fishes in Ontario Shield Lakes.**

The introduction of invasive species is among the most significant drivers of change in freshwater ecosystems. One invader, *Bythotrephes longimanus*, is a predatory invertebrate from Eurasia that was introduced into the Great Lakes in the 1980s and has since spread into inland lakes. *Bythotrephes* is an important exotic because at certain times of the year, it can consume a large proportion of the total zooplankton production and may impact food availability to other predators (e.g., forage fish). These changes at lower trophic levels may affect energy flow up the foodweb. Despite this, we know very little about how *Bythotrephes* might affect fish communities. Here, we examine the effect of *Bythotrephes* on various metrics including catch per unit effort, condition, scale inferred growth and diet of lake herring (*Coregonus arterii*) collected from invaded and reference lakes in the Muskoka area. Preliminary analyses indicate no significant difference in abundance and condition of lake herring in invaded and reference lakes (P>0.05). We expect the effect of *Bythotrephes* on growth patterns and diet of lake herring to be large. Increased knowledge regarding the effect of *Bythotrephes* on growth of forage fish is pertinent to furthering our understanding of its impact on food web dynamics. 

**Keywords:** *Bythotrephes cederstroemii*, Trophic interactions, Invasive species, Lake herring, Diets, Age and growth.
JANTUNEN, L.M., WRRIGGLESWORTH, S., and BIDLEMAN, T.F., Environment Canada, 6248 8th Line, Egbert, ON, L0L 1N0, Canada.  **HCHs in Lake Superior: Air-water Gas Exchange in 2005 Versus 1996-97.**

Parallel air and water samples were collected in the eastern half of Lake Superior in August 2005. Concentrations of $\alpha$- and $\gamma$-HCH in surface water averaged 1.45 and 0.42 ng/L, respectively. Compared to levels measured in 1996-1997, there was a factor of two decline in $\alpha$-HCH and ~30% decline in $\gamma$-HCH. HCHs in the air ranged from 34-70 pg/m$^3$ for $\alpha$-HCH and 9.9-15 pg/m$^3$ for $\gamma$-HCH, and were about a factor of two below air concentrations in August 1996. The enantiomeric fractions, $EF = (+)/[(+)+(-)]$, of $\alpha$-HCH in surface water and air averaged 0.431 and 0.450 respectively, both showing depletion of the (+) enantiomer. The EF of $\alpha$-HCH in water was significantly lower than the EF in 1996-97 (0.450), suggesting an increase in enantioselective degradation over time. Water/air fugacity ratios ranged from 2.7-7.1 for $\alpha$-HCH and 3.4-9.2 for $\gamma$-HCH, indicating net volatilization from the lake for both HCHs. In 1996-1997, fugacity ratios indicated close to equilibrium conditions for $\alpha$-HCH and net deposition for $\gamma$-HCH. EFs in water and air allowed estimation of the fraction of $\alpha$-HCH in the air boundary layer due to volatilization. **Keywords: Atmosphere-lake interaction, Pesticides, Environmental contaminants.**

JESSEN, S. and FERRARI, E. Oceans and Great Freshwater Lakes Program, CPAWS Wildlands League, 410-698 Seymour St., Vancouver, BC, V6B 3K6; Parks and Protected Areas Program, CPAWS Wildlands League, 380-401 Richmond St. West, Toronto, ON, M5W 3E8.  **Establishing an Aquatic Protected Areas Network in the Great Lakes.**

Globally, ocean and freshwater ecosystems and species are among the most threatened in the world and yet the establishment of protected areas to protect biodiversity in these ecosystems lags far behind terrestrial efforts. The vast inland freshwater seas of the Great Lakes are under increasing threat. Despite many commitments to establish aquatic protected areas to ensure long term habitat and species protection, progress on these commitments has been lacking to date. While Ontario was the first jurisdiction in Canada to create an “underwater” Provincial Park decades ago, it has since lagged far behind in the protection of aquatic ecosystems. The proclamation of the new Provincial Parks and Conservation Reserves Act in September 2007 has brought a new focus on Aquatic Protected Areas. The Canada Ontario agreement respecting the Great Lakes ecosystem and Parks Canada’s national marine conservation areas program are among the commitments and programs that provide the policy context for aquatic protected areas in the Great Lakes. These existing commitments at the federal and provincial level are described with a focus on the opportunities they provide to launch a major effort to secure significant protection of aquatic ecosystems in Ontario. **Keywords: Great Lakes basin, Conservation, Habitats.**

JOHANNSSON, O.E. 1, DERMOTT, R.M. 1, BOWEN, K.L. 1, ARTS, M.T. 2, and GERLOFSMA, J. 1, 1Fisheries and Oceans Canada, 867 Lakeshore Rd., Burlington, ON, L7R 4A6; 2Environment Canada, 867 Lakeshore Rd., Burlington, ON, L7R 4A6.  **Large Lake Monitoring: Assessment of Key Links in the Food Web.**
The optimum strategy for monitoring lakes is a combination of key sites sampled for the lower trophic levels throughout the season, and large-scale, spatial surveys for all trophic levels sampled on relevant time scales. Such endeavors are expensive and require the combined efforts of multiple agencies. One alternate strategy is to assess key links or positions in the food web. Dominant planktivores/benthivores, top carnivores (contaminants), and energetic bottlenecks are all key linkages. Fisheries and Oceans, Canada monitors *Mysis relicta* and *Diporeia*, an energetic bottleneck in the offshore community of Lake Ontario. These two species have traditionally moved the majority of planktonic production to the fish community in the offshore of the Great Lakes. We track changes in whole-lake biomass, abundance, cohort structure, fecundity and spatial patterns. Associated zooplankton sampling provides information on food levels, zooplankton community structure and potential interactions with *Bythotrephes* and *Cercopagis*. In addition, we are developing nucleic acid and essential fatty acid (EFA) indices to assess the ‘health’ of these populations. We concluded that there is significant inter-annual variability in these variables and that high nucleic acid levels correlate with high EFA concentrations. Keywords: Crustaceans, Monitoring.

JOHENGEN, T.H.¹, DEMARCHI, C.¹, CROLEY, T.E.², and HE, C.³, ¹School of Natural Resources and Environment, University of Michigan, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105-1593; ²NOAA Great Lakes Environmental Research Laboratory, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105-1593; ³Department of Geography, Western Michigan University, 3234 Wood Hall, Kalamazoo, MI, 49008-5424. Sediment and Nutrient Load Simulation for the Saginaw Bay AIF.

As part of a comprehensive study of the state of Saginaw Bay ecosystem and its possible evolution (MultiStress 07, Adaptive Integrated Framework), we are developing a sediment and nutrient load model of the Saginaw Bay watershed. The model will be based on GLERL’s Distributed Large Basin Runoff Model (DLBRM) and include simulation of point and nonpoint source nutrients generation and transport at daily and 1 km resolution. Land use has already been mapped (at 1 km² resolution) in the four watersheds that drain into Saginaw Bay using soil parameters, topography, historical daily meteorology (1948—2005). Nutrient inputs from animal manure, fertilizers, and point sources have been mapped over the same area to estimate areal distributions of nutrients. Calibration and validation of the hydrologic component of the model was also completed for 1950-1964 and 1997-2006. Calibration and validation of the nutrients model will be accomplished by supplementing the regularly monitored data with an ad-hoc sampling effort which will span two years and measure sediments and nutrients under a variety of hydrological conditions. Keywords: Watershed hydrology, Nutrients load, Water quality.

JOHNS, C., Environmental Studies Dept., St. Lawrence University, Canton, NY, 13617. Total Cadmium, Copper, and Zinc in Zebra Mussels of the Upper St. Lawrence River, 1994 through 2005.

This study assesses trends in bioaccumulation of Cd, Cu and Zn by zebra mussels at six littoral sites along the international section of the St. Lawrence River from 1994 through 2005. If contaminant loads from Lake Ontario’s outflow have been decreasing, mussels should show decreasing concentrations over time. Specific objectives include: (1) evaluation of size-specific bio-accumulation, (2) examination
of temporal and spatial variability of metal concentrations in mussels, and (3) comparison with other studies using zebra mussels in Lake Ontario and the St. Lawrence River. Mussels were collected in fall, depurated, sorted by size, digested in concentrated nitric acid, and analyzed by flame AAS along with NIST SRMs. Generally, animal size was not significantly correlated to total cadmium or zinc concentration in tissues, but was correlated with copper concentration. Levels of all three metals varied among sites and years. Highest concentrations occurred in 1994 with steep declines to relatively stable levels in subsequent years for Cd and Cu. Observed levels are consistent with decreasing loads from Lake Ontario after the mid-1990s, but concentrations remain elevated. These data provide a base from which to assess future changes in metal cycling due to global warming, lowered lake levels or seaway expansion. 

Keywords: Biomonitoring, Metals, Dreissena.

JOHNSON, T.B.\(^1\), WANG, L.\(^2\), CIBOROWSKI, J.J.H.\(^2\), and BROWNSON, B.\(^3\), \(^1\)Ontario Ministry of Natural Resources, Glenora Fisheries Station, Picton, ON, K0K 2T0; \(^2\)University of Windsor, Department of Biological Sciences, Windsor, ON, N9B 3P4; \(^3\)Ontario Ministry of Natural Resources, Biodiversity Section, Peterborough, ON, K9J 8M5. Nearshore, Small Fish Monitoring in the Great Lakes Basin.

The vast majority of fishes use the nearshore region of lakes for spawning, nursery, and/or feeding at some point in their lives. The nearshore also contains the highest fish biodiversity and is the most frequent habitat reporting new aquatic invasive fishes. We developed an online survey to assess intensity and design of nearshore, small fish monitoring in the Great Lakes basin. Over 200 individuals from all regions of the Great Lakes responded. Almost half indicated that <15% of their agency resources addressed nearshore, small fish assessment. Beach seines, electrofishing and gillnets were the preferred gears. Most programs aimed to describe species composition and abundance; 15% were directed at detection of NIS or species-at-risk (SAR). Forty-one percent felt their program had a low likelihood of detecting SAR, but only 18% inability to detect NIS, primarily due to insufficient effort (72%) devoted to suitable habitats (58%). If present, only 55% felt they would detect the NIS or SAR in the catch over 80% of the time; over 80% would ask an expert to confirm the identification. Thirty-eight percent felt programs would be modified or new programs developed (32%) to address biodiversity and invasive species issues. However, the nearshore, small fish community remains under represented in most fishery monitoring programs. Keywords: Fish populations, Assessments, Monitoring.

JOHNSTON, J.W.\(^1\), BAEDKE, S.J.\(^2\), THOMPSON, T.A.\(^3\), ARGYILAN, E.P.\(^4\), and WILCOX, D.A.\(^5\), \(^1\)Department of Geography and Environmental Studies, Wilfrid Laurier University, Waterloo, ON, N2L 3C5; \(^2\)Department of Geology and Environmental Sciences, James Madison University, Harrisonburg, VA, 22807; \(^3\)Indiana Geological Survey, Indiana University, 611 North Walnut Grove, Bloomington, IN, 47405-2208; \(^4\)Department of Geosciences, Indiana University – Northwest, 3400 Broadway, Gary, IN, 46408; \(^5\)United States Geological Survey, Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105-2807. How Do Ancient Shorelines Help in Regulation Efforts of the Upper Great Lakes?

For 17 years our research group has conducted fieldwork in remote coastal areas to build the most complete and accurate geologic framework of natural lake-level variability in the upper Great Lakes. Our work has concentrated on embayments filled with beach ridges and intervening wetlands (strandplains)
because they provide a unique lateral chronosequence. Elevations and ages are used to interpret glacial isostatic adjustment (GIA) specific to each site and a common lake-level signal within each basin through time. A five-millennial record with multi-decadal resolution is constructed for the Lake Michigan basin and is imminent for lakes Superior and Huron. Current major findings exceed previous studies by defining natural patterns and trends within a record that extends beyond instrumental records and can place historical events into context and help predict future possible scenarios. Three superimposed lake-level fluctuations (multi-decadal, centennial and millennial) occurred during the past five millennia that are coupled to natural climatic variability. Higher calculated rates of GIA from strandplains relative to instrumental gauge records raise concerns over possible biases created by not properly accounting for natural water-level variability. In addition, redefining the modern phase of the UGL’s has numerous implications. Keywords: Water level, Coasts, Paleolimnology.

JONES, E.L.¹, LEON, L.F.¹, SMITH, R.E.H.¹, CRAIG, J.R.², and CARRICK, H.J.³, ¹Dept. of Biology, University of Waterloo, 200 University Ave., Waterloo, ON, N2L 3G1; ²Dept. of Civil and Environmental Engineering, University of Waterloo, 200 University Ave., Waterloo, ON; ³Pennsylvania State University School of Forest Resources, 434 Forest Resources Building, University Park, PA, 16802. Three-dimensional Modeling of Lake-wide Nutrient and Chlorophyll Dynamics in Lake Erie Using ELCOM-CAEDYM.

Coupled three-dimensional biophysical modeling can be used as a tool for understanding the relevant hydrodynamic and biological processes that contribute to a lake’s water quality. The aim is to predict the effect of changing conditions and to simulate the input and dispersion of water quality parameters. The hydrodynamic model, ELCOM, was coupled with the ecological model, CAEDYM, to describe the processes within Lake Erie. While previous work with this model has shown success in hydrodynamic and oxygen predictions this presentation extends the validation and analysis to include nutrients (N and P) and chlorophyll. We present lake-wide water quality validation results from the coupled 2002 model showing that measured values for chlorophyll \( a \), TP, SRP, nitrate, TN, and DO agree reasonably well with computed results. Animations present the temporal and spatial variation of the simulated water quality parameters between April 11 and October 31, 2002. The model can be used to conduct numerical experiments for many different applications such as predicting lake response to climate change, assessing the ecological impacts of exotic Dreissenid mussels, and isolating the causes of hypoxia in the central basin. Keywords: Lake Erie, Hydrodynamic model, Ecosystem modeling.

JONES, M.L.¹, BRENDEN, T.O.¹, WAGNER, T.J.¹, EBENER, M.P.², ARTS, M.T.³, and FAISAL, M.⁴, ¹Quantitative Fisheries Center, Michigan State University, 13 Natural Resources Bldg., East Lansing, MI, 48824; ²Chippewa/Ottawa Resource Authority, 179 W. Three Mile Road, Sault Ste. Marie, MI, 49783; ³NWRI - Environment Canada, 867 Lakeshore Rd., P.O. Box 5050, Burlington, ON, L7R 4A6; ⁴Department of Fisheries and Wildlife, Michigan State University, 13 Natural Resources Bldg., East Lansing, MI, 48824. Natural Mortality Patterns in Lake Huron and Michigan Lake Whitefish Populations.
The commercial fishery for lake whitefish in the 1836 treaty waters of the upper Great Lakes is managed through a quota setting process that relies on statistical stock assessment models. These models assume constant values for non-fishing mortality rates based on an empirical relationship developed from a global, multi-species data set. We conducted a three-year tagging study on four lake whitefish populations in northern Lakes Michigan and Huron to directly estimate mortality rates and simultaneously collected seasonal data on a range of fish health indicators, including lipids and water content in whole fish, fatty acid profiles for three tissues, and several pathological indicators (e.g., parasites, bacteria, external and internal clinical signs of disease). Non-fishing mortality rate estimates differed among populations and deviated from the empirical estimates used in the stock assessments. Measures of fish health did not show a clear relationship with non-fishing mortality rates although lipid and fatty acid levels were generally lower, and pathogen and parasite loads generally higher in the Lake Huron populations, which also exhibited higher non-fishing mortality, particularly the Detour Village population.

Keywords: Fish tagging, Fish diseases, Lake whitefish.

JOOSSE, P.J., Ontario Ministry of Agriculture, Food and Rural Affairs, 1 Stone Road, 3SE, Guelph, ON, N1G 4Y2. Agri-environmental Research for Water Protection.

The Ontario Ministry of Agriculture, Food and Rural Affairs has a long history of funding nutrient management and other agri-environmental research in the province. Evolving provincial priorities and regulations have spurred further investigations particularly in the area of nutrient management and water protection. This presentation will highlight applied research projects being undertaken through two OMAFRA funded programs and point to where future opportunities for agri-environmental and water protection research may lie. Keywords: Nutrients, Agriculture, Research.

JUDE, D.J., HENSLER, S.R., and MINER, M.E., School of Natural Resources and Environment, University of Michigan, Ann Arbor, MI, 48109. Synergistic Effects of Ponto-Caspian Invasive Species on Warm-water Stream Fish Fauna in Southern Michigan.

Since zebra mussels became established on the Flint River, MI, but not at a control site upriver, we designed this study to identify whether introduction of zebra mussels led to round goby or darter diet or density alterations. Our results were based on data obtained prior to zebra mussel introductions (Carman et al. 2006). Fishes were collected by seining in August prior to establishment of zebra mussels (1998-1999) and after their invasion (2002). For round gobies, aquatic insects dominated the pre-zebra mussel diet (49% by number), followed by hydropsychids (7%). After zebra mussels were established, chironomids became less important in the diet (35% by volume), while hydropsychids and gastropods became more important (9% each). Zebra mussels composed 5% of the goby diet. Round gobies also consumed small fishes. At the control site, darters consumed mostly chironomids (52%) and hydropsychids (17%). Reliance on chironomids may have compromised the ability of native darters to coexist with gobies. Mussels increased water clarity and fostered higher densities of macrophytes, which was reflected in diets by the presence of large numbers of odonates. Zebra mussel-mediated ecosystem changes may have decreased interspecific competition for food with blackside darters and enhanced the ability of darters to coexist with gobies. Keywords: Lake Huron, Zebra mussels, Round goby.
Governments around the world are beginning to feel the effects of reduced water availability and the challenge of balancing needs for public water supply, agriculture, and other water uses. In response, new practices and innovative technologies are being utilized to conserve and reuse existing sources of water, with a common objective for society and individuals to function and meet specific goals with less water. Improving water efficiency at the municipal level can also lead to other benefits, including lower wastewater treatment costs, reductions in greenhouse gas emissions, and lower energy costs. This presentation will highlight some of the best available technologies and practices for water conservation in the public water sector, and draws upon a 2004 report by the Great Lakes Commission, titled “Public Sector Water Conservation: Technology and Practices outside the Great Lakes-St. Lawrence Region.” This body of research includes seven case studies of successful water conservation strategies at various levels of government from across the United States, Canada, and around the world. Initiatives and practices that will be discussed can inform the Great Lakes states and provinces as they begin to implement the provisions of the Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement. Keywords: Conservation, Water use, BMP.

Within the United States and Canada, a rising demand for alternative fuels has been spurred by high fossil fuel prices, political support and policy decisions, high corn prices, and technology improvements. Current trends have shown that the rapid expansion of biofuel production and the associated increased production of corn in the Midwest has had – and will continue to have – numerous and profound agricultural, environmental, and economic impacts. These impacts may be positive in some cases, neutral in others, and possibly negative in some instances if decisions and approaches lack foresight. Some landscape-level impacts that are already occurring may have negative consequences depending on geographic, hydrologic, climatic, and temporal factors. These include the loss or reduction of conservation lands, increased agricultural chemical applications, and increased soil erosion from conventional tillage practices. Understanding the potential impacts of biomass for biofuels production will help in the development of appropriate policy tools, as well as technology and management regimes to promote its positive impacts and mitigate its potential negative impacts. This poster is based on a research paper, entitled “The Potential Impacts of Increased Corn Production for Ethanol in the Great Lakes-St. Lawrence River Region.” Keywords: Biofuels, Environmental effects, Energy.
KAO, Y., DE MARCHI, C., ADLERSTEIN, S.A., and WILEY, M.J., School of Natural Resources and Environment, University of Michigan, 440 Church St., Ann Arbor, MI, 48104, US. **Comparison of Two Hydrological Models Used in the Great Lakes Basin.**

Two hydrological models, the Distributed Large Basin Runoff Model (DLBRM) and the Muskegon River Ecological Modeling System (MREMS), were compared in their accuracy in estimating water discharge across the Muskegon watershed. We addressed issues associated with model structure and data spatial resolution. We first compared the meteorological forcing used by the two models and then their outputs with discharges measured at five USGS gauges in the Muskegon watershed for the period 1996 to 2005. Results showed that the DLBRM overestimates average discharge, substantially in upper watershed and at a lower extent in the downstream area, but better correlates with daily flow variation. On the other hand, MREMS estimates are better at simulating long-term water balance, but they are less correlated with downstream gauges than DLBRM estimates. Difference in discharge simulation between the two models partially results from the discrepancy between precipitation forcing and simulated potential evapotranspiration. However, it is more likely derived by the different structures and calibration philosophies of the two models. More effort and inter-agency collaboration are needed to improve model robustness. **Keywords:** Lake Michigan, Model studies, Watersheds.

KARATAYEV, A.Y., BURLAKOVA, L.E., PADILLA, D.K., MASTITSKY, S.E., and OLENIN, S., Great Lakes Center, Buffalo State College, Buffalo, NY, 14222; Department of Ecology and Evolution, Stony Brook University, Stony Brook, NY, 11794; General Ecology Department, Biology Faculty, Belarusian State University, Minsk, 220030, Belarus; Coastal Research and Planning Institut, Klaipeda University, Klaipeda, Lithuania. **How Freshwater Macroinvertebrate Invaders Differ from Native Species.**

In order to succeed in a new environment an introduced species must pass through a series of filters, including biogeographic (transport to a new locale), physiological (tolerance to local abiotic conditions), and biotic barriers (interactions with species in the local community). Although many species have the potential to be introduced, only a few pass all filters and establish populations in a new environment, suggesting that invaders may not be a random selection of species. To examine the role of species characteristics in invasion, we assembled information on 119 freshwater macroinvertebrate invaders and compared them to native species. We found that invaders are generally more tolerant to organic pollution than many native species, have high percentage of suspension feeders and are over represented by molluscs and crustaceans. Native communities are dominated by insects, which are rarely found as aquatic invaders. We suggested that the current spread of invaders could be facilitated by a reduction in water quality, which may reduce the biodiversity of native communities due to the extirpation of species that require high water quality. Because these patterns and processes are very similar in the New and Old World, we suggest that the observed patterns are likely to hold globally. **Keywords:** Invasive species, Macroinvertebrates, Pollution.

KAYLE, K.A., Ohio Department of Natural Resources, Division of Wildlife, 1190 High St., Fairport Harbor, OH, 44077. **Population Dynamics of Steelhead in Lake Erie.**
Life history characteristics of steelhead stocked in Lake Erie are not well understood. Biologists examined steelhead from private sport and charter catches in cleaning stations from June through September, 2002-2005. Age information was gathered from scales and otoliths. During the study, we analyzed 225 length-weight samples and 301 hard part samples for determining ages. I determined that fish spending their third summer in the lake were the greatest contributors to the fishery, followed by those spending their second and fourth summers. Fish residing up to seven summers in the lake were sampled. From the age and growth data, a significant length:weight relationship for steelhead was determined. With logistic growth data, I estimated annual natural mortality (M) at 0.74-0.77. I developed a population estimator based on estimates of total mortality (Z) and survival (S) from catch-curve analysis, the number of fish stocked and estimates of natural reproduction. These initial model estimates place the Lake Erie steelhead population aged one summer and older at around 1.1 million fish (range 0.5-2.8 million), depending on the survival estimates used in the model. This study’s information will assist Lake Erie task groups in bioenergetics modeling and examining spatiotemporal overlap and consumptive demand for forage. Keywords: Lake Erie, Trout, Fish populations.

KELCH, D.O. and SNYDER, F.L., Ohio Sea Grant College Program, Ohio State University Extension, 1314 Kinnear Road, Columbus, OH, 43212-1194. Twenty Years Post-invasion: Overview of Impacts from Dreissensids on Recreational Users in Lake Erie.

Since their discovery in the Great Lakes during 1988, zebra and quagga mussels (Dreissena spp.) have had numerous impacts on water based recreational activities; some positive, most negative. Being filter feeders of phytoplankton and zooplankton, zebra mussels disrupt aquatic food chains for larval and juvenile sport fishes. Lake Erie sportfishery assessment data indicate 20 years of both population and angler catch rate change, some of which can be attributed to dreissenid food chain impacts. Dreissenid filtering has also increased visibility; in some areas as much as 600 percent. Increased light penetration has resulted in new grow of submerged aquatic macrophytes, changing habitats in nearshore areas and marinas. It has also impacted the feeding habits of the light sensitive walleye, resulting in changes to traditional angling practices. Boaters and scuba divers realize impacts from dreissenids. Boat hull and water intake fouling has resulted in increased prevention and repair cost to boaters. Heavy knee pads are now standard gear for scuba divers in preventing both injury and wetsuit damage. Increased visibility benefits divers, yet heavy concentrations of dreissenids covering shipwrecks, in addition to potential deterioration of wreck structures, may negate the benefit of increased visibility. Keywords: Zebra mussels, Lake Erie, Recreational.

KENDALL, S.T.¹, RUBERG, S.A.², and BIDDANDA, B.A.¹, ¹Annis Water Resources Institute, Grand Valley State University, 740 W. Shoreline Dr., Muskegon, MI, 49441; ²National Oceanic and Atmospheric Administration, Great Lakes Environmental Research Lab, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105. Physical–chemical Characterization of a Nearshore Submerged Sinkhole Ecosystem in Lake Huron.
We conducted field surveys in 2006 and 2007 to map the unique features of a submerged karst sinkhole ecosystem located 4 km offshore near Rockport, MI in Lake Huron where groundwater (GW) is venting and purple cyanobacterial mats dominate the lake floor. Aerial and bathymetric surveys revealed a ~23 m deep and ~90 m wide sinkhole (arena). A smaller collapse area (alcove) exists as a pocket into the arena wall separated by a 4.3 m rock wall. Diver/ROV surveys showed GW forming a dense shimmering layer overlain by lake water. Continuous time-series data from sondes during mid-summer showed arena GW, relative to lake water, to be lower in temperature (10 v 18°C), pH (7.3 v 8.3), DO (4 v >11 mg/L), and ORP (150 v 500 mV), and higher in specific conductance (1.7 v 0.3 mS/cm). Temperature probes deployed 1 m and 4 m from the bottom in spring during isothermal conditions shows arena GW to be warmer relative to lake water (7.4 v 5.0°C). Warmer arena temperatures at 1m typical of GW were observed during upwelling events. Arena GW layer was ~1 m thick and gradually thinned to the open lake area. Alcove GW DO was much lower (<0.4 mg/L) and specific conductance higher (2.3 mS/cm). Alcove GW fills the alcove bowl and spills over into the arena. The distribution of purple cyanobacterial benthic mats was limited to the extent of GW influence. **Keywords:** Benthic flora, Bathymetry, Biogeochemistry, Karst sinkholes, Coastal ecosystems, Lake Huron.

**KING, J.W.**, 1, **SHUMCHENIA, E.J.**, 1, **MOE, H.**, 1, **LEWIS, C.F.M.**, 1, **SLATTERY, S.R.**, 2, **GOODYEAR, D.R.**, 2, and **KILGOUR, B.** 3, 1University of Rhode Island, Graduate School of Oceanography, South Ferry Rd., Narragansett, RI, 2882; 2Lake Simcoe Region Conservation Authority, 120 Bayview Parkway, Box 282, Newmarket, ON, L3Y 4X1; 3Stantec Consulting, 1505 Laperriere Ave., Ottawa, ON, K1Z 7T1. **Characterizing Habitat in Kempenfelt Bay, Lake Simcoe.**

A habitat mapping study was undertaken using a Benthos C3D interferometric sonar system that simultaneously acquired 3D bathymetry and side scan sonar data. The sidescan sonar data were used to identify different acoustic signatures of bottom types. A preliminary map of polygons of different bottom types was then produced. The bathymetry data were processed using CARIS HIPS to create a 3D bathymetry model. To delineate habitat types, we ground-truthed the acoustic data with grab samples, sediment profile images (SPI), and underwater video. Grab samples provided a description of sediment grain size and the types of infauna and epifauna. Traditional benthic analyses of the grabs provided identification and counts of benthic organisms. SPI was used to determine the amount of oxidized sediment and degree of bioturbation. The underwater video camera was used to evaluate the surface activity of the benthos and their percent cover. These data were combined to create maps of sediment type, and distribution of dominant organisms. This was a feasibility study to evaluate methods and develop a protocol for habitat mapping in Lake Simcoe. **Keywords:** Acoustics, Benthos, Habitats.

**KLINE, W.T.**, 413 McGilvrey Hall, Kent, OH, 44242. **Rapid Shifts in the Great Lakes Region's Cloud Cover Associated with the Approach of Winter.**

The Great Lakes region of the United States is an area of great climatic diversity. Research analyzing diurnal temperature range has noted that in late autumn and early winter there is an abrupt decrease in the temperature range for stations near the Great Lakes. One underlying reason for this decrease is low-level cloud cover due to the “lake effect,” although little research has evaluated this
decrease and its variability in time and magnitude. Through determining the timing of late autumn and early winter cloud cover throughout the Great Lakes, it will be possible to better understand this dramatic drop in diurnal temperature range and help determine a time window for its arrival. In order to assess this variability, a few measures have been used. Frequencies of spatial synoptic classification weather types (SSC) for greater than three dozen stations will be analyzed. In addition, cloud cover data for low-level clouds (LLC) have been utilized from first order stations in the Great Lakes region in order to compare timing of low-level cloud days in relation to present weather types. Variability of cloud cover by phase of PNA and NAO is also addressed. Keywords: Climate trends, Cloud cover, Synoptic climatology.


Lake Winnipeg is the 10th largest lake in North America, 11th in the world by surface area, and constitutes a valuable freshwater resource for the province of Manitoba. It supports a large commercial fishery and is a drinking water source for several First Nations communities near the lake. In past 10-15 years, cyanobacterial blooms have increased in size and magnitude, composed of various morphological species in the Aphanizomenon flos-aquae complex (mainly morphotypes comparable to A. flos aquae, A. klebahnii, A. yesoense, A. cf flexuosum, and A. hungaricum), as well as other heterocystous types such as Anabaena lemmermannii, A. spiroides, A. mendotae, A. flos-aquae. More recently (post 2003), there has been an increased occurrence of Microcystis species such as M. botrys, M. flos aquae, M. novacekii, as well as the oscillatoriales Pseudanabaena catenata and epiphytic Pseudanabaena species in the lake. In addition to this increased cyanobacterial presence, species changes have been noticed in other algal classes (especially diatoms) with considerable year-to-year variability. This paper describes the succession of some of the species or species complexes currently dominant in Lake Winnipeg, and recent changes which have occurred in relation to water quality issues. Keywords: Lake Winnipeg, Phytoplankton, Cyanophyta.

KOCOVSKY, P.M.1, STAPANIAN, M.A.1, and KNIGHT, C.T.2, 1USGS Lake Erie Biological Station, 6100 Columbus Ave., Sandusky, OH, 44870; 2ODNR Fairport Fisheries Research Station, 1190 High St., Fairport Harbor, OH, 44077. Evaluating Sampling Regimens for Indices of Yellow Perch Abundance in Lake Erie.

We examined catches of YOY and age-1 yellow perch sampled at three depths and three times of day in summer and autumn 1986-2006 in western Lake Erie to determine if sampling at some depths or times of day could be eliminated while not affecting the management value of abundance indices. We calculated $r^2$ and estimated abundance ($N_{est}$) from regression models that project abundance of age-2 yellow perch using indices calculated from the full sampling regimen (i.e., sampling all times of day and all three depths) and from 48 reduced regimens for four indices of abundance: summer YOY, summer age
1, autumn YOY, autumn age 1. We calculated $\Delta r^2$ and $\Delta N_{est}$ between the full regimen and each reduced regimen and tested whether either differed from zero. Eliminating night sampling, alone or in conjunction with morning or afternoon, always resulted in $\Delta r^2 < 0$, suggesting poorer performance using all four indices. There were no trends in $\Delta N_{est}$ for the reduced regimens. Of the 10 reduced regimens for which $\Delta r^2 > 0$ for at least 3 of 4 indices, greatest cost savings occurred for sampling only at night. We recommend night sampling for monitoring programs for yellow perch. Keywords: Lake Erie, Yellow perch, Sampling.

KOOPS, M.A. 1, SUTTON, T.M. 2, ARTS, M.T. 3, MUIR, A.M. 4, CLARAMUNT, R.M. 5, EBENER, M.P. 6, FITZSIMONS, J.D. 1, JOHNSON, T.B. 7, and KINNUNEN, R.E. 8, 1Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, Burlington, ON; 2School of Fisheries and Oceans Science, University of Alaska Fairbanks, Fairbanks, AK; 3National Water Research Institute, Environment Canada, Burlington, ON; 4Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN; 5Charlevoix Fisheries Research Station, Michigan Department of Natural Resources, Charlevoix, MI; 6Inter-Tribal Fisheries and Assessment Program, Chippewa-Ottawa Resource Authority, Sault Ste. Marie, MI; 7Glenora Fisheries Station, Ontario Ministry of Natural Resources, Picton, ON; 8Michigan Sea Grant Extension, Michigan State University, Marquette, MI. Implications of Ecosystem Change for the Life History of Lake Whitefish.

Recent ecological changes in the Great Lakes, starting with invasion by dreissenids (Dreissena polymorpha and D. bugensis) and subsequent declines in Diporeia (an important, abundant, lipid rich amphipod) have resulted in poorer condition lake whitefish (Coregonus clupeaformis). We examine the influence that condition has on the life history of lake whitefish, specifically examining growth and reproduction. We found that condition, as measured by essential fatty acids, had an influence on the growth and reproductive investment of female lake whitefish; with females in poorer condition exhibiting slower growth but investing relatively more in reproduction. This increased reproductive investment was observed in both the number and size of eggs produced. We conclude that female lake whitefish are trading off current and future reproductive opportunities and that recent environmental changes in the Great Lakes are decreasing the value of the future and increasing the relative value of current reproductive opportunities. Keywords: Life history studies, Lake whitefish, Great Lakes basin.

KOVALCIK, P.K., Biohabitats, Inc., 2081 Clipper Park Road, Baltimore, MD, 21211. Muskegon Lake, Ruddiman Creek and Nearby Shoreline Ecological Restoration Master Plan: Using Stakeholder Involvement to Derive the Goals and Objectives for Addressing Beneficial Use Impairments in an Area of Concern.

USEPA and Biohabitats, Inc. in collaboration with multiple stakeholders have created a restoration master plan for Ruddiman Creek and the nearby shoreline of Muskegon Lake, in Muskegon Michigan. The area has been degraded as a result of shoreline fill, sediment contamination, and unregulated stormwater runoff. It is part of the Muskegon Lake Area of Concern and is listed as having Beneficial Use Impairments including loss of fish and wildlife habitat, degradation of fish and wildlife populations, and degradation of benthos. A sediment remediation effort was completed in Ruddiman Creek in 2006; however, additional restoration is necessary to address the Beneficial Use Impairments.
The Ecological Restoration Master Plan provides actions for the restoration of fish, wildlife, benthic habitats, water quality and human uses. These actions are intended to create ecosystem resiliency, diversity, and attract reproducing populations of desirable native species. Stakeholder collaboration and community involvement were essential in the plan process. Their participation is critical when balancing private interests with restoration and conservation objectives. This plan is the outline for addressing Beneficial Use Impairments within this Area of Concern and ultimately, a template for restoring degraded habitats in the Great Lakes. Keywords: Habitats, Lake Michigan, Planning.

KRAMKOWSKI-EPNER, V.1 and CULOTTI, J.2, 1Faculty of Environmental Studies, York University, Toronto; 2Samuel Lunenfeld Research Institute, Mount Sinai Hospital, Toronto. Is C. elegans a Promising Bioindicator for Water Quality Studies? Examining Its Use in Toronto River Systems.

Caenorhabditis elegans, a microscopic nematode widely used in genetics, also holds potential for water quality testing. Yet while many studies examine contaminant concentration-response relationships in liquid media, few studies use C. elegans as a bioindicator in field samples. A common protocol has also not been established for raising worms in aquatic media. The C. elegans strain CL2070 was used to monitor water quality in the Humber and Don Rivers in Toronto. CL2070 expresses Green Fluorescence Protein (GFP) in contact with heavy metals. Counting both mortality and GFP expression provided a more sensitive assay than mortality alone. Water samples were collected at each site and time point, filtered, and worms were raised in samples for 96 hours. Current protocols were improved by the use of alternate control media such as double-distilled water and various concentrations of M9 buffer, presenting a fairer control than liquid media. CL2070 expressed GFP erratically between sites and samples. Mortality was also variable in samples and controls and did not usually correspond with GFP expression. While these indicators were sometimes consistent within the same sample, variability in control mortality raises doubts about past studies that suggest C. elegans is an ideal water quality bioindicator. Keywords: Bioindicators, Experimental design, Water quality.

KRANTZBERG, G., McMaster University, 1280 Main St. W., Hamilton, ON, L2S 4K1. Civic Engagement in Delisting Areas of Concern.

This analysis of local capacity to achieve consensus and sustain momentum to complete RAP implementation is based on the cleanup that led to Collingwood Harbour being delisted in 1994, the first of then 43 locations to achieve this milestone. RAP implementation and progress toward watershed management can thrive with strong local leadership. In this case, governments acted as facilitators and partnership builders of the RAP and provide resources and technical assistance to leverage local and private sector resources. The people that participated in improving their harbor were integral to success. Keys to delisting included the participation of the community leaders, the development of a mutually agreed upon decision making process, common objectives and purpose, dispute resolution mechanisms, political support, participatory decision making and funding. This case study will demonstrate the role of civic engagement in successful delisting of an Area of Concern, central to making the lakes great. Keywords: Ecosystem health, Environmental policy, Remediation.
KRAUS, D.T.\textsuperscript{1} and KLEIN, D.F.\textsuperscript{2}, \textsuperscript{1}5420 Highway 6 N, RR No. 5, Guelph, ON, NiH 6J2; \textsuperscript{2}1048 University Ave., Rochester, NY, 14607. \textbf{A Biodiversity Conservation Strategy for Lake Ontario.}

In support of the Lake Ontario Lakewide Management Plan, a bi-national partnership involving 27 public and private agencies and organizations from Ontario and New York has held four workshops to develop a bi-national biodiversity conservation strategy for the lake and upper St. Lawrence River. This process has identified conservation targets (species-guilds and natural systems that represent the biodiversity of the lake ecosystem), assessed target viability, clarified threats to the continued viability of targets, and proposed place-based and basin-wide strategies to abate key threats and enhance the health of biodiversity targets. Target natural systems and species include the benthic and pelagic zones, nearshore zone and embayments, coastal wetlands, coastal terrestrial communities, migratory fish, tributaries, and islands. Draft strategies will be presented, including priorities for land protection and best management within watersheds and coastal sub-units. \textit{Keywords: Biodiversity, Conservation, Planning.}

KREMENS, R.L.\textsuperscript{1}, DRAKE, R.\textsuperscript{2}, HOVEY, A.\textsuperscript{3}, BOVE, G.E.\textsuperscript{4}, and TOMKINS-TINCH, C.H.\textsuperscript{1}, \textsuperscript{1}Rochester Institute of Technology, 54 Lomb Memorial Dr., Rochester, NY, 14623; \textsuperscript{2}Buffalo Niagara RiverKeepers, Buffalo, NY; \textsuperscript{3}Buffalo City School System, Buffalo, NY; \textsuperscript{4}State University of New York at Buffalo, Buffalo, NY. \textbf{Inexpensive Buoys for Environmental Education and River Water Quality Assessment.}

We have developed a multi-purpose buoy system to monitor the gross physical characteristics (water temperature, turbidity, and color) related to water quality in the Buffalo River system. These buoys are inexpensive, easy to deploy from a small craft and have a short range telemetry system that allows continuous, real time, Web-based observation of measured parameters. The custom electronics package is powered for up to 4 weeks by dry cells which are easily replaced during sensor servicing. The buoys serve several purposes; high time resolution monitoring of the physical characteristics of the river; as an “episodic trigger” for remote airborne or ground based data collections (which provide synoptic and detailed data, respectively) during industrial release, sewage overflow or other pollution generating events; and as a source of real time environmental data for educational use by the Buffalo city public school system. Triggered by buoy data, we can deploy one of several aircraft equipped with multi-spectral sensors and/or request that a volunteer field crew (organized by the Buffalo-Niagara Riverkeepers) collect water samples for laboratory analysis. We will show results from the buoy including overhead imagery of the river, time histories of physical parameters from the buoys, and the Web-based data interface. \textit{Keywords: Buoys, Remote sensing, Environmental education.}

KRIEGER, K.A.\textsuperscript{1}, BUR, M.T.\textsuperscript{2}, STEARNS, A.M.\textsuperscript{1}, and EDWARDS, W.H.\textsuperscript{2}, \textsuperscript{1}National Center for Water Quality Research, Heidelberg College, Tiffin, OH, 44883; \textsuperscript{2}U.S. Geological Survey, Lake Erie Biological Station, Sandusky, OH, 44870. \textbf{Nearshore Hypoxia in Lake Erie’s Central Basin: A Proposed Lake Quality Indicator.}
The quality of the benthic invertebrate community, which serves as a food base for Lake Erie fishes, continues to be degraded in the central basin. We hypothesize that hypoxia is the primary factor preventing development of a “healthy” zoobenthic community in relatively shallow nearshore areas. During thermal stratification in 2006 and 2007, we recorded rapid (hours to days) appearance and disappearance of anoxia (<1 mg/L) within 1 m of the bottom at fixed stations as shallow as 10 m along two transects that extended from 1 km near shore to 12 km off shore (7.5 m to 17.5 m deep) near Lorain, Ohio. The areas of anoxia appeared to be localized and physically uncoupled from the primary zone of anoxia (“dead zone”), which is farther offshore in deeper water. The relatively brief intervals of anoxia were of sufficient duration to prevent survival of various zoobenthic taxa of value in fish diets. We propose a new “nearshore anoxia” indicator for the central basin of Lake Erie. It would be defined as the frequency of finding anoxia within 1 m of the lake bottom in shallow (<15 m) nearshore areas during the mid- to late-summer period of thermal stratification. Strategies for selecting number of stations, station locations, and sampling frequency would depend on scientific and management objectives.

Keywords: Oxygen, Anoxia, Ecosystem health, Zoobenthos, Monitoring, Hypoxia.

The objective of this study was to determine chiral herbicides mecoprop, dichlorprop, and metolachlor in Ontario streams and the Great Lakes. In samples above the detection limit, (+) mecoprop was preferentially depleted in 50% of the samples, (–) mecoprop in 43%, and racemic mecoprop occurred in 7% (n=72). Depletion of (+) dichlorprop was favored in 90% of the samples and (-) enantiomer in 10% (n=10). No samples contained racemic dichlorprop. Metolachlor stereoisomers were detected in 167 stream water, 51 Great Lake surface water and 9 precipitation samples. Average S/R ratios (ratio of herbicidally active/inactive stereoisomers; sum of two S-stereoisomers to sum of two R-stereoisomers) were 8.65±2.22, 6.86±2.23, and 2.99±1.24 for precipitation, stream water, and lake water, respectively. It is interesting that the S/R ratio in precipitation was similar to that in commercial S-metolachlor (S/R ~ 9) whereas the S/R ratios in stream water and lake water differed from commercial S-metolachlor in displaying lower enrichments of active C*S,aR and C*S,aS diastereomers. At this point, we do not know whether the observed S/R profiles in stream water and lake water are due a mixture of S-metolachlor and formerly used (before 2001) racemic metolachlor, or if some stereoselective degradation has taken place.

Keywords: Pesticides, Mecoprop, Dichlorprop, Metolachlor, Great Lakes basin, Great Lakes rivers, Chiral signatures.

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The objective of this study was to determine chiral herbicides mecoprop, dichlorprop, and metolachlor in Ontario streams and the Great Lakes. In samples above the detection limit, (+) mecoprop was preferentially depleted in 50% of the samples, (–) mecoprop in 43%, and racemic mecoprop occurred in 7% (n=72). Depletion of (+) dichlorprop was favored in 90% of the samples and (-) enantiomer in 10% (n=10). No samples contained racemic dichlorprop. Metolachlor stereoisomers were detected in 167 stream water, 51 Great Lake surface water and 9 precipitation samples. Average S/R ratios (ratio of herbicidally active/inactive stereoisomers; sum of two S-stereoisomers to sum of two R-stereoisomers) were 8.65±2.22, 6.86±2.23, and 2.99±1.24 for precipitation, stream water, and lake water, respectively. It is interesting that the S/R ratio in precipitation was similar to that in commercial S-metolachlor (S/R ~ 9) whereas the S/R ratios in stream water and lake water differed from commercial S-metolachlor in displaying lower enrichments of active C*S,aR and C*S,aS diastereomers. At this point, we do not know whether the observed S/R profiles in stream water and lake water are due a mixture of S-metolachlor and formerly used (before 2001) racemic metolachlor, or if some stereoselective degradation has taken place.

Keywords: Pesticides, Mecoprop, Dichlorprop, Metolachlor, Great Lakes basin, Great Lakes rivers, Chiral signatures.
The diverse fish community which inhabits Lake Simcoe is of considerable ecological and economic significance. The lake is the focus of one of Ontario, Canada’s most intensive inland sport fisheries, with a large proportion of angling effort directed at the coldwater fish community. Lake Simcoe’s coldwater fish community has undergone dramatic changes over the past few decades, attributed to accelerated eutrophication and coldwater habitat degradation. Long-term fisheries monitoring projects conducted by the Ontario Ministry of Natural Resources, Lake Simcoe Fisheries Assessment Unit (LSFAU), have documented recruitment failures in lake trout (*Salvelinus namaycush*) during the 1950s, lake whitefish (*Coregonus clupeaformis*) during the 1960s, and lake herring (*Coregonus artedi*) in the 1980s. Each event was followed by drastic declines in abundance for these species and their scarcity has persisted into the early 2000s. Lake Simcoe’s lake trout and lake whitefish populations have been maintained through supplemental stocking. Monitoring conducted since 2001 has confirmed a limited amount of natural reproduction and survival by wild lake trout and suggests some successful reproduction by lake whitefish. We will review historical changes in Lake Simcoe’s coldwater fish community and report on its current status. **Keywords:** Fish populations, Lake Simcoe, Recruitment.

LABENCKI, T.L. and BOYD, D., Ontario Ministry of the Environment, Environmental Monitoring & Reporting Branch, 125 Resources Road, Toronto, ON, M9P 3V6. **PCB Contributions to Hamilton Harbour.**

The Hamilton Harbour Area of Concern (AOC) has a number of Beneficial Use Impairments (BUIs), including restrictions on fish and wildlife consumption which is driven by elevated levels of PCBs in sport fish. In order to further understand the role of current versus historical PCB loadings in Hamilton Harbour’s foodweb, event-based sampling at major tributaries and the wastewater treatment plants was conducted by the Ontario Ministry of Environment in 2007; water samples were also collected from two locations within the harbor. Preliminary results are not indicative of a large, locally-controllable PCB source to the harbor as PCB concentrations in inflow waters that were sampled are consistent with urban background concentrations. In addition, as PCB concentrations in the harbor were generally equal to or greater than concentrations in inflow waters, existing accumulations of PCB in harbor sediments are likely playing a large role in keeping PCB concentrations relatively high in harbor waters. This suggests historical loadings remain important in the PCB dynamics of limnologically-unique Hamilton Harbour, which has implications for delisting the associated BUI. **Keywords:** PCBs, Urban watersheds, Hamilton Harbour, Fish consumption restrictions.

LAKFARD, S. ¹ and FRASER, G.S. ², ¹Biology Department, York University, 4700 Keele St., Toronto, ON, M3J 1P3; ²Faculty of Environmental Studies, York University, 4700 Keele St., Toronto, ON, M3J 1P3. **Nesting Ecology of Common Terns at Tommy Thompson Park, Toronto, Ontario.**

During the summer 2007 we conducted a behavioral ecology study of common terns, *Sterna hirundo*, at Tommy Thompson Park (TTP), Toronto, Ontario. Common terns at TTP nest on small islands in embayments and floating platforms (n= 96 nests). The purpose of our study was to identify significant sources of disturbance and quantify various breeding behaviors such as feeding rates to mates and chicks
and nesting productivity for the two nesting substrates (2 islands, 2 platforms). Fish identification was done through opportunistic photographs. Sources of disturbance included birds flying over the nest sites (mallards, egrets, and herons) and human disturbances (visiting people, vehicles, especially big trucks and small airplanes). Courtship and chick feeding rates for the platforms was 0.15 and 0.29 per hour, respectively. For the islands, courtship and chick feeding rates was 0.13 and 0.06 per hour respectively. Productivity rate for the observed platforms was 0.7 chicks per nest and for the islands 0.46 chicks per nest. The common terns’ diet consisted of 25.7% Notropis atherinoides, 10% Alosa pseudoharengus, 10% Neogobius melanostomus, 2.1% Osmerus mordax, 1.4% Perca flavescens, 0.7 % Ameiurus nebulosus, 0.7% Notropis hudsonius, 0.7 % Lepomis gibbosus, 7.1% from genus Notropis and 41.4% of unknown fish species. Keywords: Lake Ontario, Avian ecology.

LANTRY, B.F., WALSH, M.G., O’GORMAN, R., JOHNSON, J.H., and MCKENNA, JR., J.E., 1USGS Lake Ontario Biological Station, 17 Lake St., Oswego, NY, 13126; 2USGS Tunison Laboratory of Aquatic Science, 3075 Gracie Road, Cortland, NY, 13045. Occurrence of the Great Lake’s Most Recent Invader, Hemimysis anomala, in the Diet of Fishes in Southeastern Lake Ontario.

Hemimysis anomala is a small mysid similar to the Great Lake’s only native mysid, Mysis relicta. Originally native to freshwater areas of the Black, Azov, and Caspian Seas, in 2006, it was first reported from the Great Lakes at two widely separated locations, east-central Lake Michigan and southeastern Lake Ontario. In Europe, Hemimysis are normally found in lakes, but have colonized some rivers and canals. Similar to M. relicta, Hemimysis are photonegative omnivores that migrate from near bottom during the day to near the surface at night. In 2007, we caught a large number of Hemimysis in southeastern Lake Ontario by towing a 1-m square net at night. During the summer and fall of 2007 we used gill nets and seines to catch potential fish predators of Hemimysis at sites along the southeastern and eastern shores. Stomachs were collected from yellow perch, rock bass, smallmouth bass, round gobies, alewives, and spottail shiners. Alewives, yellow perch, and rock bass consumed Hemimysis, and stomachs of alewives were often full of the new invader. Herein we briefly overview our Hemimysis sampling efforts and the diet composition of fish predators from our samples. Keywords: Invasive species, Food chains, Lake Ontario.

LASHAWAY, A.R. and CARRICK, H.J., School of Forest Resources, Pennsylvania State University, University Park, PA, 16802. Diatom Rejuvenation and Hypoxia in Lake Erie.

Rapid sedimentation of phytoplankton cells following surface blooms is common in the Great Lakes, yet their fate is uncertain, particularly in Lake Erie, where hypoxia occurs seasonally. Our previous work shows planktonic diatom species dominating the benthic assemblage in the central basin. The objectives are two-fold: 1) evaluate and compare the cytological condition of diatoms through the water column and on the bottom of the lake, and 2) determine rejuvenation rates for dominant diatoms present in the sediments. Seasonal sampling was done for both water column and benthos at stations inside and outside of the hypoxic area in the central basin of Lake Erie (May to October). Variation in diatom abundance, cytological condition (vegetative, resting, dead), and rejuvenation rates (from enclosure experiments) were examined. The density of planktonic diatoms on the bottom of the lake declined from
June through September (thermally stratified period) and the proportion of resting and dead cells became more prevalent. Further, we anticipate the rate of diatom rejuvenation (resting to vegetative state) will be most swift in the spring and the fall periods. If diatoms are able to withstand low oxygen concentrations and ultimately rejuvenate into fully operating vegetative cells, they may not be the main culprit to hypoxic conditions. **Keywords:** Diatoms, Lake Erie, Benthos, Resting cells.

LAVOIE, R.A.¹, HILL, L.¹, YUMVIHOZE, E.¹, RAIL, J.F.², and LEAN, D.R.S.¹, ¹University of Ottawa, 30 Marie-Curie, P.O. Box 450, Station A, Ottawa, ON, K1N 6N5; ²Environment Canada, Canadian Wildlife Service, 1141 route de l'Église, P.O. Box 10 100, Québec, QC, G1V 4H5. **Insights on the Distribution of Mercury in a Gulf of St. Lawrence Food Web from Stable Nitrogen and Carbon Isotope Analysis.**

Mercury (Hg) is a chemical of concern because of its persistence, toxicity, and biomagnification potential in the environment. Details of its distribution and pathways in food chains are still poorly understood, especially in estuarine ecosystems. The general objective of this study is to determine the main variables of the feeding ecology that are driving the concentration of total (THg) and methyl-mercury (MeHg) in a Gulf of St. Lawrence estuarine food web. THg and MeHg levels were measured in representative species from primary consumers (zooplankton and molluscs) to top-level predators (seabirds). Stable nitrogen and carbon isotope analyses were used to provide information on the trophic level and the source of the organic matter (benthic vs. pelagic), respectively. We found that the source of the organic matter was a minor but significant contributor to Hg concentrations with higher values found in organisms feeding in the benthic zone. Trophic level was found to be the main contributor. This suggests that elevated Hg concentrations are more likely to be associated with high trophic level species that feed in the benthic zone. This study will help to identify the mechanisms of Hg accumulation in the Gulf of St. Lawrence food web and to develop predictions on the influence of environmental perturbations. **Keywords:** Isotope studies, Mercury, Food chains.


In October 2007 the Maumee Remedial Action Plan (RAP) Committee observed the twenty year anniversary of the designation of the Maumee Area of Concern (AOC) located in NW Ohio. The two decades have seen significant progress and continued challenges toward resolving the Beneficial Use Impairments (BUIs) initially identified in the Maumee AOC. This paper will provide a review of the progress by the Maumee RAP within the Maumee AOC and assess the accomplishments and activities toward delisting. Recent events include the creation of Partners for Clean Streams Inc. (PCS) as the new 501c3 non-profit entity for water planning and merger of the Maumee RAP Advisory Committee into PCS. In 2007 PCS was awarded a grant of $588,000 from the Joyce Foundation to undertake three urban watershed restoration projects within the Maumee AOC. A ten step program is outlined to evaluate watershed planning efforts within the Maumee AOC as a guide to a continued success and to provide
suggestions to other Great Lakes Areas of Concern and watershed planning initiatives within the basin.

*Keywords: Watersheds, Environmental policy, Lake Erie.*

LEBLOND, S.S., HAMILTON, K., RUTTER, A., and CAMPBELL, L.M., Queen's University, Bioscience Complex, Queen's University, Kingston, ON, K7L 3N6. **Metal Contamination Sources and Fate within the Rideau River Waterway.**

The Rideau River Waterway is comprised of a series of lakes connecting the Ottawa River to the Cataraqui River in Kingston. In 2006, a preliminary study evaluated the sediment and water metal concentrations, grain size (GS) and organic content (OC) of nine lakes south of Smith Falls. Within Upper Rideau (UR) and Indian Lake (IL), Pb was found to exceed CCME Sediment Guidelines, while Co and Zn were found to exceed CCME Freshwater Guidelines. Elevated concentrations of Cu, Co, Ni, Zn and Rb (0.003 to 0.073 ppm) were found in waters, but were not correlated with sediment concentrations or GS (in all but one instance). Significant regressions between sediment OC and metal concentrations were found only for Cu, Co, and Rb (p-values 0.0290, 0.0095, and 0.0013 respectively). There were significant correlations between Hg and Cr and between Cd, Pb, and Zn sediment concentrations across locations (p < 0.001). While Hg was not detected in tested waters, it ranged between 0.067 and 0.253 ppm in sediments. The OME records for UR and IL indicate that average Hg concentrations in sport fish exceed recommended guidelines for at-risk groups (0.789 and 0.356 µg/g respectively). This study examines the distribution of metals within two highly utilized lake systems and seeks to identify potential contamination sources and management options. *Keywords: Biomagnification, Environmental contaminants, Metals.*

LEKKI, J.L.1, LESHKEVICH, G.2, NGUYEN, Q.V.1, FLATICO, F.3, PROKOP, N.1, ANDERSON, R.1, DEMERS, J.1, KOJIMA, J.3, KRASOWSKI, M.1, and OO, O.1, 1NASA Glenn Research Center, 2100 Brookpark Rd., Brookpark, OH, 44135; 2NOAA Great Lakes Env. Res. Lab., 2205 Commonwealth Blvd., Ann Arbor, MI, 48105; 3Ohio Aerospace Institute, 22800 Cedar Point Rd., Brookpark, OH, 44142. **Update on Great Lakes Hyperspectral Water Quality Instrument Suite for Airborne Monitoring of Algal Blooms.**

NASA Glenn Research Center and NOAA Great Lakes Environmental Research Lab have continued their collaboration to utilize an airborne hyperspectral imaging sensor suite to monitor algal blooms in the western basin of Lake Erie and Saginaw Bay. The development of a bloom is a very dynamic event because the bloom can form, spread, and then disappear within a 4 to 8 week time period in late summer. They are a concern for human health, fish, and wildlife because they can contain blue green toxic algae. This situation is well suited for aircraft-based monitoring because the blooms are such a dynamic event and they can spread over a large area. A second generation custom designed hyperspectral imager and a point spectrometer mounted in a Lear 25 aircraft have been used to obtain data of multiple areas in the western basin of Lake Erie during September 2007. Water samples have been taken of these same areas concurrently by NOAA and the EPA. The correlation of the water samples with the hyperspectral measurements will help to determine the efficacy of hyperspectral monitoring of harmful algal blooms in the Great Lakes. The sensor suite and operations will be described and preliminary
hyperspectral data of this event will be presented. Keywords: Remote sensing, Microcystis, Harmful algal blooms.


Dichlorodiphenyltrichloroethane (DDT) was primarily used as a pesticide in Canada from the 1940s through to the 1970s until it was banned in 1985 due to the bioaccumulative nature of the chemical. The Holland Marsh is an area of intensive crop farming in Southern Ontario. DDT monitoring completed on fish tissues collected from the Holland Marsh in the 1970s detected concentrations of DDT that exceeded 5,000 μg/kg. High concentrations were also noted in water and soil samples obtained in the Marsh during the same time period. In 2006/07 Semi Permeable Membrane Devices (SPMD) were deployed for 1 month to assess the bioconcentration potential of DDT in the Holland Marsh canals and surrounding watercourses. In order to interpret the severity of the results on aquatic biota a method was developed to compare SPMD values with federal fish tissue guidelines. Resulting SPMD values were corrected for the density of the triolein medium used in each device and corrected for the difference in uptake rates of DDT by SPMDs over fish tissues. DDT was detected at all locations with a greater number of guideline exceedences in the 2006 data as compared to 2007. The use of SPMDs prove to be an effective technique to monitor the bioconcentration of DDT without the need to sample aquatic biota. Keywords: SPMDs, Pesticides, DDT, Monitoring.

LENTERS, J.D., University of Nebraska-Lincoln, School of Natural Resources, Lincoln, NE, 68583. Long-term Trends in the Seasonal Water Balance of Lakes Erie and Michigan-Huron: Is There a “Disconnect” at the St. Clair River?

Previous studies of Great Lakes water levels have identified shifts in the seasonal rise and fall of the lakes, from Lake Superior on down to Lake Ontario. In general, the Great Lakes region has shown a trend toward earlier (and drier) springs and wetter autumns, leading to an earlier rise and fall of Lakes Erie and Ontario. Lakes Superior and Michigan-Huron, on the other hand, show a reduction in the amplitude of the annual cycle, rather than a shift earlier in time. For Lake Michigan-Huron, this is partly due to changes in connecting-channel flow through the St. Clair River. The changes are also found in the Detroit River, thereby impacting the water balance of Lake Erie. In this study, an analysis of the water budgets of Lakes Michigan-Huron and Erie are presented to understand the mechanisms responsible for the observed changes in seasonality over the past 60+ years. Changes in precipitation and runoff in each basin are found to lead to many of the observed long-term shifts in seasonal lake level. Variations in connecting-channel flow through the St. Clair and Detroit Rivers, however, contribute greatly to the earlier rise and fall of Lake Erie. Due to the loss of water from Lake Michigan-Huron, the effect upstream is reversed, resulting in a “disconnect” between the upper and lower lakes. Keywords: Climate change, Hydrologic cycle, Water level fluctuations.
LEON, L.F., HIGGINS, S., SMITH, R.E.H., LAM, D.C., and HIPSEY, M. 1University of Waterloo, 200 University West, Waterloo, ON, N2L 3G1; 2National Water Research Institute, 867 Lakeshore Rd., Burlington, ON, L7R 4A6; 3Center for Water Research, University of Western Australia, Perth, WA, Australia. Simulating Water Quality in Eastern Lake Erie for Coupled Modeling.

A project with OPG for the vicinity of the Pickering nuclear plant to study algal growth, transport and detachment, calls for the use of a hydrodynamic model coupled to a water quality component. Current research involves the use of ELCOM (3D-hydrodynamics) coupled to CAEDYM (water quality) to simulate the input conditions for modeling Cladophora growth, detachment, and transport in the coastal zone of Lake Erie. This model suite has been applied in the eastern basin of Lake Erie to simulate nutrients (phosphorus and nitrogen) dynamics and other water quality parameters such as dissolved oxygen, chlorophyll $a$, and suspended solids. In order to capture the nearshore dynamics in detail, a high-resolution grid has been developed and nested within coarse grid simulations. This means that the output from a coarse grid (2 km) is used to force the boundaries of a smaller, higher resolution domain (200 m). This work presents the fine tuning and validation of the output from the ELCOM-CAEDYM simulations for the main parameters that the CGM requires as input. Keywords: Model studies, Lake Erie, Hydrodynamics.


CoastWatch is a nationwide National Oceanic and Atmospheric Administration (NOAA) program within which the Great Lakes Environmental Research Laboratory (GLERL) functions as the CoastWatch Great Lakes regional node. In this capacity, GLERL obtains, produces, and delivers environmental data and products for near real-time monitoring of the Great Lakes to support environmental science, decision making, and supporting research. This is achieved by providing Internet access to near real-time and retrospective satellite observations, in-situ data, and derived products to Federal and state agencies, academic institutions, and the public via the CoastWatch Great Lakes web site (http://coastwatch.glerl.noaa.gov). New utilities such as JAVA GIS and Google Earth® 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 image products such as an improved temperature composite chart, satellite derived wind fields, ice type mapping, turbidity, and chlorophyll images derived from satellite sensors such as Synthetic Aperture Radar (SAR), scatterometer, and ocean color sensors. Keywords: Remote sensing, Satellite technology, Monitoring.

Lake Simcoe Sediment Architecture: Evidence for a Lowstand During Early Holocene Dry Climate.

Seismic reflection profiles from the 1990s have delineated a sediment and hydrogeological stratigraphy up to 50 m in places beneath the lake floor that relate to the paleo-environmental history of the basin through glaciation, subglacial meltwater erosion, glacial lake deposition, and postglacial lake sedimentation. In zones 10 to 25 m below lake level, but not deeper, reflections in the lowermost postglacial lake (Lake Simcoe) sediments and uppermost glacial lake (Lake Algonquin) sediments are truncated, indicating a period of erosion. The erosion is interpreted to have resulted from wave abrasion in an early Holocene lowstand of the lake. Wave-base calculations for storm conditions indicate that the water surface at the time could have been 13 m above the level of deepest erosion. This level appears to have been about 7 m below the overflow outlet near Orillia, suggesting the lake was closed hydrologically, a result that is consistent with the drier-than-present early Holocene climate. The acoustic evidence for the lowstand was confirmed in 2007 when sediment cores for further testing of the lowstand hypothesis were recovered. Keywords: Paleolimnology, Holocene, Climate change.


Pharmaceuticals and personal care products (PPCPs) and endocrine disruptor substances (EDS) are contaminants of emerging concern that are discharged into the Great Lakes by municipal wastewater treatment plants. The recently developed POCIS technology may provide an effective means of monitoring for hydrophilic polar contaminants of emerging concern in the aquatic environment. In this study, POCIS samplers were deployed in the nearshore zone in Lake Ontario and in Lake Erie to monitor a range of PPCPs and EDS, including neutral drugs, beta-blocker drugs, sulfonamide antibiotics, acidic drugs, triclosan and triclocarban, selective serotonin reuptake inhibitor (SSRI) anti-depressants, estrogens, alkylphenols and bisphenol A. The POCIS were deployed for 1 month at several stations in western Lake Ontario in the summer of 2006, and in Lake Erie near Port Stanley in the summer of 2007. Most of the classes of PPCPs and EDS were detected by liquid chromatography tandem mass spectrometry (LC-MS/MS) in the POCIS extracts. The neutral drugs, caffeine and carbamazepine, and the SSRI drug, venlafaxine were the compounds detected at the highest concentrations, ranging from 9.0 to 181.5 ng per POCIS. Spatial trends in the distribution of contaminants in the POCIS reflected the wastewater sources of these compounds. Keywords: Environmental contaminants, Chemical analysis, LC-MS/MS, PPCPs and EDS.

Li, H.1, METCALFE, C.D.1, and HELM, P.2, 1Trent University, 1600 West Bank Dr., Peterborough, ON, K9J 7B8, Canada; 2Ontario Ministry of the Environment, 125 Resources Road, Toronto, ON, M9P 3V6, Canada. Monitoring Nearshore Contamination in Lake Ontario and Lake Erie Using Polar Passive (POCIS) Samplers.

LIAO, Q.1, BOOTSMA, H.A.2, XIAO, J.E.1, and KLAMP, V.J.2, 1Department of Civil Engineering and Mechanics, University of Wisconsin-Milwaukee, Milwaukee, WI, 53092; 2Great Lakes WATER Institute,
A low-cost non-tethered submersible PIV system has been developed to measure small-scale flow structures in turbulent environmental flows. The system consists of a CW DPSS laser (532 nm), a scanning mirror (galvanometer), a CCD camera with GigE interface, an ultra-compact PC for data acquisition and a USB signal-generating device that controls and synchronizes all components. All the components are battery-powered and can be fitted into a small underwater housing. The capability of the underwater PIV system has been demonstrated through a couple of field deployments in Lake Michigan. 2D turbulent velocity field (20 by 20 cm) is resolved on a plane perpendicular to the lake bottom, which is covered by Dreissenid mussels. Measurement results, including the vertical profiles of mean velocity, Reynolds stress, dissipation rate and the turbulent flux of particles (phytoplankton and sediment particles), will be presented and discussed. Keywords: Hydrodynamics, Turbulence, Waves, Lake Michigan.

The Lake Erie charter fishing industry provides important angler access to Lake Erie sport fishing and is economically important to local recreational harbor communities. Economic data on the charter industry is useful in helping to provide an economic rationale for harbor dredging. In early 2007, we conducted a mail survey of 517 randomly selected Ohio charter boat captains and received usable information from 249 captains. In 2006, there were 786 Ohio licensed charter guides. This is a decline of nine percent from the 861 licensed captains in 2002. Charter firms in 2006 made on average 2.6 more trips per firm (44.7) than in 2002 (42.1). These captains made an estimated 28,519 charter trips in 2006 of which almost 87% were full day and just over 13% were half-day trips. About 76% of the charter clientele were repeat customers. Almost 81% of Ohio charter customers come from over 50 miles or further away from the charter firm’s homeport bringing nature based tourism dollars into local lakefront communities. This is the sixth survey conducted by Ohio Sea Grant of the Ohio charter industry dating back to 1985. Keywords: Lake Erie, Fishing, Economic evaluation.

Diel patterns of vertical distribution of fish and of zooplankton along with estimated consumption determined from bioenergetics models were used to determine predatory interactions among *Bythotrephes*
*longimanus, Cercopagis pengoi,* fishes, and zooplankton along an offshore-onshore transect in southern Lake Michigan. Vertical spatial overlap between alewives, their preferred prey *Bythotrephes,* and zooplankton were strongly driven by thermal structure, however the pattern of vertical distribution was not consistent or stable during the day or night. *Bythotrephes* and *Cercopagis* were usually found concentrated in the epilimnion and to a lesser degree in the metalimnion, while adult alewives were generally found lower in the water column. By migrating deeply during the day, *Daphnia* mostly avoided the visually feeding *Bythotrephes,* but generally had a higher spatial overlap with fish. The low abundance of alewives and their lower position in the water column relative to *Bythotrephes* allowed *Bythotrephes* to be abundant offshore, where they likely controlled *Cercopagis* abundance through predation. Estimates of consumption of zooplankton showed that *Bythotrephes* dominated the offshore while *Cercopagis* and fish dominated consumption inshore. *Keywords: Lake Michigan, Bythotrephes cederstroemii, Predation.*

LIVERSEDGE, L.K., Michigan Tech Research Institute, 3600 Green Court, Suite 100, Ann Arbor, MI, 48105. **Turbidity Mapping and Prediction in Glacial Lakes.**

Lakes associated with glacial environments typically contain large amounts of rock flower – suspended sediment originating from glacial rock weathering. This rock flower is discernable in satellite images and is easily measured in situ. Turbidity mapping and prediction using remote sensing has had limited success in the past due to the type of aquatic system under investigation, remote sensing platform used, and geographical area of study. Using an autonomous robot buoy and a multiple linear regression analysis, an accurate and repeatable algorithm to predict turbidity in northern, glacial lakes has been developed. The algorithm utilizes Landsat 7 ETM+ Band 3 and Band 4 data to predict turbidity concentrations. The algorithm was developed specifically for Vitus Lake, a lake approximately the size of Lake St. Clair located in coastal south-central Alaska at the terminus of the Bering Glacier, but is also applicable to other glaciated lakes. The success of the algorithm is attributable to the highly oligotrophic status of glacial lakes, and it was found that delineation of turbidity concentrations in these environments is more straightforward and accurate than similar efforts in temperate or tropical climates where biology typically drives aquatic systems and strongly affects the remotely sensed optical signal. *Keywords: Turbidity, Remote sensing, GIS.*

LOFGREN, B.M., NOAA/Great Lakes Environmental Research Lab, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105. **Atmospheric and Hydrologic Impacts of Increased Greenhouse Gases on the Great Lakes Simulated Using CHARM2.**

The new version of the Coupled Hydrosphere-Atmosphere Research Model (CHARM) incorporates several new features. There is spectral nudging in the interior of the model domain in addition to lateral boundary nudging. Surface heat flux adjustment is calibrated and applied on the Great Lakes in order to bring their surface temperatures into agreement with observations during the historical time period. Preliminary results will be presented of comparisons between runs at different times driven by output from the National Center for Atmospheric Research's Community Climate System Model version 3.0 (CCSM 3.0). Output variables will include air and water temperatures, wind, precipitation,
evapotranspiration, ice cover, and runoff. Keywords: Atmosphere-lake interaction, Hydrologic budget, Climate change.


Porewater was extracted at 10 cm intervals from two piston cores collected from Lake Simcoe, and its oxygen- and hydrogen-isotope compositions measured. The first core (44.38°N, 079.67°W; water depth, 24 m; core length, 5.12 m) was taken near the head of Kempenfelt Bay, where groundwater seepage into Lake Simcoe has been suggested from seismic reflection data. The second core (44.49°N, 079.42°W; water depth, 21 m; core length, 7.61 m) was taken from the main basin of Lake Simcoe. The δ¹⁸O and δD values of porewater from the second core range from -7.8 to -6.9‰ and -61 to -52‰, respectively, decreasing gradually toward the bottom of the core. The isotopic compositions cluster slightly to the right of the Great Lakes Regional Meteoric Water Line, reflecting the evaporative enrichment known for Lake Huron and Lake Simcoe. A much wider range of δ¹⁸O (-11.9 to -7.6‰) and δD (-85 to -57‰) values was obtained for porewater from the Kempenfelt Bay core. These results describe a mixing line between regional groundwater (δ¹⁸O = -11.3‰, δD = -81‰) and porewater from the main basin of Lake Simcoe. Groundwater dominates the porewater above 3 m. The interval between 3 and 4 m is dominated by lake water. Below that, mixing has occurred between the two reservoirs. Keywords: Stable isotopes, Lake Simcoe, Groundwater.


Phosphorus (P) is often the limiting nutrient for phytoplankton growth in the Great Lakes. P is mostly readily available to phytoplankton as phosphate (Pi) but cells can use monophosphate esters which are cleaved by alkaline phosphatase activity (APA). Recent research suggests marine cyanobacteria can also use phosphonates, which were previously considered unavailable for phytoplankton. To examine phosphonate use by Great Lakes cyanobacteria, we conducted growth trials using isolated cyanobacterial strains, and a range of P compounds including the phosphonates 1-aminoethylphosphonic acid, phosphonoacetic acid and glyphosate. Growth of cells was monitored over 2 weeks by chl a fluorescence changes. Pi concentration and APA were also measured. Strains showed APA and a marked ability to cleave Pi from monophosphate ester glycerol-Pi. Relative to the growth rate when supplied with Pi, growth rate ranges were 14-36% with glycerol-Pi, and 17-35% with phosphonates. A bioassay with P sources was also carried out with natural Lake Michigan water, which showed similar results to cultures - phosphonates stimulated more growth than in samples with no added P. Great Lakes cyanobacterial
communities can clearly utilize phosphonates as a P source which has important implications for runoff of agricultural phosphonates into lake catchments. **Keywords:** Lake Michigan, Phytoplankton, Phosphorus.

LU, Q.¹, DUCETT, F.¹, NAIRN, R.B.¹, and TAYLOR, S.², ¹Baird & Associates, 627 Lyons Lane, Suite 200, Oakville, ON, L6J 5Z7; ²Essex Region Conservation Authority, 360 Fairview Avenue West, Suite 311, Essex, ON, N8M 1Y6. 3D Hydrodynamic Modeling in Huron and Erie Corridor (HEC).

A three dimensional model for the Huron and Erie Corridor has been developed using the MISED model. The MISED model is a 3D hydrodynamic and sediment transport model using a modern numerical method developed by Dr. Lu (1998). The method was proved to be unconditionally stable and computationally efficient. The model domain covers the southern part of Lake Huron, the St. Clair River, Lake St. Clair, the Detroit River, the western part of Lake Erie, and includes the major tributaries. The grid resolution ranges from 10 m to 2000 m. The developed model was linked to the POM models in NOAA Great Lakes Operation Forecast System (GLOFS) in both Lakes Huron and Erie and filled the gaps of the GLOFS. The spatially and temporally varying wind was used to simulate the impacts of storm surges on the currents in the Detroit River. Compared with the ADCP data measured in the St. Clair and Detroit Rivers, the model predicts the currents well. The reverse flow in the Detroit River and the St. Clair Delta were well simulated by the model. The model has been used for Canadian source water protection studies. **Keywords:** Lake St. Clair, St. Clair River, Lake Huron, Hydrodynamic model, Detroit River, Lake Erie.

LUDEWIG, B.G.¹ and AUSTIN, J.A.², ¹Water Resources Science, University of Minnesota, Duluth, Duluth, MN, 55812; ²Large Lakes Observatory, University of Minnesota-Duluth, Duluth, MN, 55812. Upwelling in Idealized Stratified Lakes.

Wind driven circulation in lakes is expected to respond variably to rotational effects depending on lake size and shape. We use numerical modeling techniques to characterize these effects in idealized, thermally stratified fresh water lakes. Length and width are both important in determining rotational effects: length scales must be sufficient for significant deflections to occur, while width must not be so small as to constrain transverse circulation. Rotational effects become important at length scales of a few times the internal radius of deformation. Circulation, specifically the location and magnitude of upwelling events, affects nutrient distribution and biological activity, and ultimately the sedimentation patterns in a lake. An understanding of the effects of lake size and shape can lead to an improved ability to infer wind direction and to make other interpretations of paleorecords in the sediments of the world’s ancient lakes. **Keywords:** Paleolimnology, Computer models, Hydrodynamics.

LUDSIN, S.A.¹, HÖÖK, T.O.², RUCINSKI, D.K.³, DEPINTO, J.V.⁴, and SCAVIA, D.⁵, ¹Aquatic Ecology Laboratory, Dept. of Evolution, Ecology, & Organismal Biology, The Ohio State University, Columbus, OH, 43212; ²Cooperative Institute for Limnology and Ecosystems Research, University of Michigan and NOAA-GLERL, Ann Arbor, MI, 48105; ³Limno-Tech, Inc., School of Natural Resources and Environment, University of Michigan, Ann Arbor, MI, 48108; ⁴Limno-Tech, Inc., 501 Avis Dr., Ann
Historical Exploration of Hypoxia Effects on Fish Recruitment and Production in Lake Erie.

Hypolimnetic hypoxia (< 4 mg O₂/L) is a natural phenomenon in Lake Erie’s central basin during late summer; however, its magnitude, extent, and duration can vary inter-annually. While it is plausible that fish populations will respond to such annual variation in hypoxia, the effect of hypoxia on Lake Erie’s recreational and commercial fisheries remains poorly understood. Herein, we characterize historical relationships between hypoxia and growth, recruitment, and harvest levels of central Lake Erie’s dominant piscivore (walleye *Sander vitreus*), benthivore (yellow perch *Perca flavescens*), and planktivore (rainbow smelt *Osmerus mordax*), using both statistical and computer modeling approaches. Specifically, we use a regression approach to quantify the historical (1987-2007) relationship between 1) annual indices of growth (length at age), recruitment, and population biomass for these species and 2) indices of the magnitude, spatial extent, and duration of bottom hypoxia, generated from empirical field observations and output from a one-dimensional water quality model. Based on results from our analyses, we discuss how hypoxia may influence our ability to understand (and hence forecast) both past and future dynamics of these three recreationally and commercially important fish populations. Keywords: Oxygen, Yellow perch, Fish populations, Rainbow smelt, Recruitment, Walleye.


Caspian terns nesting in the Great Lakes since World War II have been subject to a significant organohalogen contamination gradient across their breeding distribution. Recapture of 1,065 terns banded as chicks showed a recruitment pattern after 1966, inversely correlated to exposures to total PCBs and TCDD-EQs in a dose-dependant manner. Similarly, banding mortality series of terns banded as chicks and terns banded as adults indicated much lower survival with high contaminant exposures during nesting. A tern chick raised in the cleaner regions of Lake Huron was 2.5 times more likely to mature and return to nest than a chick from Green Bay and 5.9 times more likely than a chick from Saginaw Bay. Rapid post-fledgling mortality of chicks in areas of greater exposure was probably related to changes in brain dopamine neurotransmitter concentrations and severe immune suppression in fledglings. Other traditional habitat factors were not correlated to recruitment. The cause-effect hypothesis that recruitment was not related to contaminant exposures was rejected in favor of a conclusion that recruitment was driven primarily by contaminant exposures, not other physical habitat factors, between 1966 and 1995. Keywords: Bioaccumulation, Recruitment, PCBs.

LUDWIG, J.P., ERRC, Ltd., 607 Canard St., Port Williams, NS, B0P 1T0. Survival and Recruitment in Double-crested Cormorants from the Upper Great Lakes 1977-2007: Relationships with Contaminants.

The survival and recruitment of adult double-crested cormorants was measured through recoveries in a mortality series of 1,758 cormorants banded between 1978 and 1995 when a total of about 72,000
cormorant chicks were banded in the upper Great Lakes. Recruitment and survival to breeding age correlated inversely to contaminant exposures of embryos. Areas of intense contamination, especially Saginaw Bay, Thunder Bay of Lake Huron, and Green Bay of Lake Michigan produced fewer birds that matured to adult ages similar to Caspian terns across the same geographic distribution and contamination gradient. Banding data indicate the lower Great Lakes colonies in Lakes Erie and Ontario were less productive of birds reaching adult ages than those of the cleaner areas of Lakes Huron and Superior; northern Lake Michigan colonies had productivity greater than the more contaminated areas, but less than the cleaner areas of northern Lake Huron, the North Channel, Georgian Bay and Lake Superior. As with lake trout and Caspian terns, contaminants, particularly total PCBs and TCDD-EQs appear to have driven survival and recruitment in this population. Keywords: Cormorants, Recruitment, PCBs.

LUMB, C.E.¹, FRANZIN, W.G.², and WATKINSON, D.A.², ¹Manitoba Water Stewardship, Fisheries Branch, 200 Saulteaux Crescent, Winnipeg, MB, R3J 3W3; ²Fisheries and Oceans Canada, Freshwater Institute, 501 University Crescent, Winnipeg, MB, R3T 2N6. Distribution and Abundance of Small-bodied Fishes in Lake Winnipeg.

Lake Winnipeg is the tenth largest freshwater lake in the world, by surface area, and the third largest lake completely within Canada. It is a shallow, turbid lake that does not typically thermally stratify. The lake is divided into two distinct basins: the North Basin has a larger surface area and greater mean depth (13.3 m) than the South Basin (9.7 m). The lake supports important subsistence, recreational and commercial fisheries. Despite ecological, social and economic importance, dynamics of the fish community are not well understood. To describe distribution and abundance of small-bodied fishes in open waters of Lake Winnipeg, trawling was conducted near long term monitoring stations during seasonal research cruises using a 3-meter square beam trawl. Rainbow smelt (Osmerus mordax) dominated catches from the North Basin, while emerald shiners (Notropis atherinoides) were most abundant in the South Basin. Emerald shiners, cisco (Coregonus artedi) and walleye (Sander vitreus) contributed to catches from both basins, but were more abundant in the South Basin. Rainbow smelt were almost absent from catches in the South Basin. Data will be used to describe distribution and abundance of forage and commercially important species, like juvenile walleye/sauger (Sander canadensis). Keywords: Species composition, Fish, Lake Winnipeg.

MACISAAC, H.J., Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, N9B3P4. Developments in Invasion Ecology.

The modern field of invasion ecology began with publication of Charles Elton's seminal book in 1958, though the field did not experience growth until the early 1990s. Since that time, there has been an exponential increase in publication of papers pertaining to invasions of both aquatic and terrestrial ecosystems. During the late 1980s, concern in the Great Lakes focused on invasion by the Eurasian ruffe, although subsequent invasions by dreissenid mussels quickly changed academic, government and industrial interests. Global publications on dreissenids have increased from a background level of <10/yr (1972-1990) to current levels of ~150 paper/yr. Total Dreissena citations have increased from <100/yr to ~3,500/year during this time. While studies on dreissenid mussels have clearly expanded, they parallel a
global trend that applies to many other taxa and highlight the growing importance of this “new” global stressor. The widespread impact of dreissend mussels has fostered development of numerous invasion concepts including human-mediated dispersal models, and facilitative interactions amongst invaders. Efforts to curtail invasions must begin with arguably the most important step, vector control. 

Keywords: Dreissena, Biological invasions, Invasive species.

MACKEY, S.D.1, MACDOUGALL, T.M.2, and MARKHAM, J.L.3, 137045 N. Ganster Road, Habitat Solutions NA, Beach Park, IL, 60087; 2Box 429, 1 Passmore Ave., Ontario Ministry of Natural Resources, Port Dover, ON, N0A 1N0; 3178 Point Drive North, NYS Department of Environmental Conservation, Dunkirk, NY, 14048. Preliminary Assessment of Lake Trout Spawning Habitat in the Eastern Basin of Lake Erie.

More than 615 line km of sidescan sonar and underwater video data were collected from seven potential lake trout spawning areas identified by GIS during the summer of 2007. Six of these areas were located along the Canadian north shore between Port Maitland and Nanticoke in the eastern basin of Lake Erie. The seventh area was located over Brocton Shoal near Dunkirk, New York. These data were processed, mosaicked, and used to identify, characterize, and map substrate types and bottom characteristics analogous to known lake trout spawning areas in the eastern basin of Lake Erie and other Great Lakes. The Canadian north shore can be characterized by broad bedrock platforms intersected by incised sand-filled paleochannels. Boulder-cobble deposits comprised of eroded bedrock material are commonly found on the edges of these platforms, which are adjacent to potential deeper-water nursery areas. Glacially-derived coarse-grained deposits are locally distributed across many of these bedrock features in Canada and at Brocton Shoal. Underwater video shows multiple sites with habitat characteristics similar to other lake trout spawning sites. However, the dominant presence of dressenids, round gobies, and Cladophora on these substrates may significantly reduce lake trout spawning and recruitment potential at these sites. Keywords: Habitats, Sidescan sonar, Lake trout, Lake Erie.

MANNING, N.F., University of Toledo Lake Erie Center, 6200 Bayshore Dr., Oregon, OH. Hydrology and Plant Community Alterations in Wetlands of the Cuyahoga Valley National Park.

The hydrology of wetlands is a key abiotic factor in the determination of the type of wetland and the maintenance of these important ecosystems. By understanding the typical hydrologic and ecological response of these systems at a landscape scale it may be possible to predict how groups of similar wetlands will behave when large scale impacts are planned. This research was conducted in the Cuyahoga Valley National Park (CVNP), within the Lake Erie watershed in northern Summit and southern Cuyahoga counties in northeastern Ohio. Sixteen wetlands were selected for this project. Monitoring wells were used to monitor water levels within the sites as well as determining the variance and range of water level for each site. A modified Vegetative Index of Biotic Integrity (VIBI) protocol was used to collect plant community data. Analysis of Covariance (ANCOVA) and Principal Component Analysis (PCA) were used to determine the interactions of several different environmental factors in disturbed and undisturbed wetlands. The results of this study show that there is a strong interaction effect between disturbance and environmental factors such as wetland and watershed size, and wetland type. This
interaction makes it possible to begin to predict the reaction of different wetland types when human impacts encroach on natural area. **Keywords:** Wetlands, Lake Erie, Urban watersheds.

**MANNO, J.P.**¹ and **KRANTZBERG, G.**², ¹State University of New York ESF, 211A Marshall Hall, Syracuse, NY, 13210; ²McMaster University, School of Engineering Practice, Hamilton, ON, ON, L8S 4L7. **Toward a Management and Accountability Structure for the GL Ecosystem.**

In the Great Lakes Water Quality Agreement (GLWQA) the Canadian and U.S. governments agreed to adopt an ecosystem approach to managing the Great Lakes. Such an approach at the minimum requires an understanding of ecosystem dynamics and an ability to carry out coordinated, ecologically rational policy interventions to accomplish ecosystem-based goals. Currently the governments are considering a range of options for improving Great Lakes management including, potentially, revisions to the GLWQA. We will report on the preliminary results of our project involving interviews, expert workshops and analysis of international water regimes centered on questions of governance, accountability, representation, political will, financing and others. We focused on a range of functions required for effective ecosystem based management: leadership, community building and maintenance, accountability, education, problem scoping and framing, and organizational management. We will report on options for improving the functioning of the Great Lakes regime and its capacity to manage the Great Lakes ecosystem. **Keywords:** Ecosystems, Policy making, Management.

**MANNO, J.P.**¹, **DEPINTO, J.V.**², **SMARDON, R.**¹, **CLOYD, E.T.**³, and **DEL GRANADO, S.M.**¹, ¹Forestry Drive #1, Syracuse, NY, 13210, US; ²501 Avis Dr., Ann Arbor, MI, 48108, US; ³1717 Pennsylvania Ave. Suite 250, Washington, DC, 20006, US. **The Development and Use of Predictive Models in Great Lakes Decision Making: An Interdisciplinary Synthesis.**

The Great Lakes basin is one of the most modeled systems in the world. Computer simulation models have been used since the 1970s in several areas including pollution control, fish stocking, and water level regulation, and their uses range from increasing the understanding of a system to serving as decision support tools. To examine how computer simulation models were used in decision-making processes, thirty-five interviews were conducted and documents were reviewed in relation to four cases in the Great Lakes in which models were an important feature: Phosphorus loadings (1970s); Mass Balance-PCBs (1980s); Lake Ontario Fish Stocking (1990s); and Water Level Regulation in Lake Ontario and the Saint Lawrence River (2000s). We found that environmental decision making could be improved by technological advances in modeling and its increasing availability. Specific findings include: planning and managing the modeling process is as important as focusing on decreasing output’s uncertainty; managers need to provide clear direction, while modelers must be careful not to promise more than can be delivered; model objectives and complexity should be decided and agreed upon; ambiguity at the beginning of a process can undermine chances for success; and models should and could constitute spaces for participants’ deliberation and education. **Keywords:** Policy making, Decision making, Model studies.
Alkaline phosphatase activity is an exolytic enzyme generally secreted by bacteria during periods of phosphorus starvation to generate free phosphate groups from dissolved organic phosphorus compounds. Thus, alkaline phosphatase activity is a good indicator of phosphorus limitation. The purpose of this study was to address the question of P-limitation in the Sandusky Bay/Sub-basin ecosystem. Samples were taken from six sites starting upstream (on the Sandusky River) and ending offshore (in Sandusky Subbasin) during the summers of 2006-2007. The samples were then analyzed for whole water alkaline phosphatase activity using the 4-methylumbelliferyl phosphate method. Generally APA activity was higher earlier in the season, and declined later in the season. The 2007 season showed much higher APA activity than did the 2006 season. The offshore site showed the highest APA activity and could be considered P-Limited, while the bay and river samples where often not P-limited. From the data collected, no strong correlations could be discerned with regard to dissolved organic phosphorus, or total phosphorus concentrations. Keywords: Phosphorus, Nutrients, Alkaline phosphatase.
Centered in heavily-industrialized East Chicago is the Indiana Harbor and Ship Canal. Branching off of the southwestern edge of Lake Michigan, the waterway is known to be contaminated with polychlorinated biphenyls (PCBs) and is designated as an Area of Concern by the International Joint Commission. PCBs can be metabolized to the hydroxylated form (OH-PCBs) by humans and other organisms, and it is probable that PCBs in the sediment are metabolized by microbial activity. This may be a removal mechanism for PCBs in sediment. Alternatively, OH-PCBs may come from exogenous sources. Yet OH-PCBs in sediment have not been reported. We hypothesize that OH-PCBs are present in the contaminated canal and harbor sediment. A method for the extraction and analysis of these OH-PCBs was developed. Herein we present preliminary results of OH-PCB congeners in surficial sediment of Indiana Harbor and Ship Canal. **Keywords:** Hydroxylated PCBs, Sediment, Urban areas.

**MARKLEVITZ, S.A.C.**, **MORBHEY, Y.E.**, and **FRYER, B.J.**

**The Differentiation of Chinook Salmon in Natal Streams of Lake Huron: The Use of Otolith Microchemistry as a Natural Tag.**

Chinook salmon were introduced to the Laurentian Great lakes to increase the diversity of angling opportunities in 1873, and have been extensively stocked since 1967. In Lake Huron, the Great Lakes Fishery Commission has supported large scale Chinook salmon stocking programs since 1968, and the population now consists of wild stream-reared and hatchery-reared fish. Tracking of hatchery salmon traditionally utilized the labor intensive method of fin clipping and/or tagging. However, the use of fin clips and tag release studies are not practical methods of tracking wild populations which spawn in streams throughout the watershed. The objective of our study is to differentiate the stream of origin in Lake Huron Chinook salmon by examining the microchemistry of otoliths. Recent studies have shown relationships between the elemental composition of otoliths in teleost fish and the environment. The biologically inert and archival properties of the otolith allow for the analysis of the environmental conditions throughout the life history of an individual fish. We will examine fry collected from various streams of different geological and geographical regions and relate otolith microchemistry to elemental composition of the local water. The information gathered will be used to determine the stream origin of adult Chinook salmon. **Keywords:** Lake Huron, Salmon, Geochemistry.

**MARSDEN, J.** and **ELSTER, M.**

**Remedial Action Plans for Great Lakes Areas of Concern: Status, Current Issues, and Delisting Outlook.**

With the most recent signing of the revised Great Lakes Water Quality Agreement (GLWQA) in 1987, the governments of Canada and the United States committed to develop and implement Remedial Action Plans (RAPs) for Great Lakes Areas of Concern (AOCs). Of the forty remaining AOCs, twenty-five are in the U.S., ten are in Canada, and five are shared binationally. As described in Annex 2 of the GLWQA, environmental problems in AOCs are addressed using an ecosystem approach. Restoring impaired Beneficial Uses and delisting an AOC is a process that includes problem definition,
development and implementation of remedial actions, and monitoring to confirm restoration. Using the same process, RAPs have necessarily evolved to engage state and provincial government agencies and local communities, while the development and implementation of the RAPs has occurred in a manner unique to each AOC. RAPs have made significant progress, are currently addressing a variety of issues, and present a range of outlooks for delisting. Keywords: Remediation, Cleanup, Decision making.

MARS DEN, J.E. 1, SMITH, S.J. 2, and HATT, J. 1, 1University of Vermont, Rubenstein School of Environment and Natural Resources, Burlington, VT, 5405; 2Lake Champlain Fish and Wildlife Resources Office, 11 Lincoln St., Essex Junction, VT, 5452. Lake Whitefish and Zebra Mussels in Lake Champlain: One Up, One Down, No Connection?

Lake whitefish populations in the Great Lakes have declined recently, in part due to loss of Diporeia and diet shifts to dressenids. The U.S. whitefish commercial fishery in Lake Champlain closed in 1912, but commercial fishing in Quebec waters (Missisquoi Bay) continued until 2004. However, no scientific studies of whitefish have been conducted since 1931. Diporeia is rare in Lake Champlain, and zebra mussels invaded in 1993. We compiled historic data and sampled lake whitefish to assess their population status and examine changes in diet. Commercial harvest declined steadily in Missisquoi Bay since the late 1980s; lamprey wounding was high. We sampled adult whitefish in fall using gillnets, and larval whitefish were sampled in spring with an ichthyoplankton net. We found no whitefish adults or larvae at traditional fall commercial fishing sites. Spawners and larvae were sampled in high densities at one site; only one adult was found elsewhere. The age structure of sampled adults was broad, condition factor was good (mean K = 1.2), and mean GSI was 16%. Diets were primarily small gastropods, similar to diets in the 1930s; zebra mussels were consumed very rarely. Whitefish have not apparently been affected by changes in the benthos in Lake Champlain, but spawning stocks appear to have been depleted. Keywords: Zebra mussels, Whitefish, Diets.

MART IN, P. 1, MCDANIEL, T. 1, and WILLIAMS, N. 2, 1Box 505, 867 Lakeshore Road, Burlington, ON, L7R 4A6; 2Walpole Heritage Centre, Rural Route 3, Wallaceburg, ON, N8A 4K9. Assessment of Beneficial Use Impairments in a Model Amphibian, Northern Leopard Frogs, in the St. Clair Area of Concern.

The St. Clair River between Sarnia and Lake St. Clair and the territory of the Walpole Island First Nation (WIFN) has been designated by the International Joint Commission as an Area of Concern (AOC), due to high levels of contamination in the sediments from present day and historical industrial activity, raising questions about potential impacts to wildlife health. Potential beneficial use impairments (BUIs) to wildlife in the St. Clair AOC include wildlife deformities and reproductive impairments and degradation of wildlife populations as measured by contaminant body burdens. Northern leopard frogs were used as a representative amphibian species to assess these BUIs at sites within and upstream of the St. Clair AOC in 2006 and 2007. Survivorship was high and deformity rates were low in leopard frog eggs raised in water from both AOC and upstream sites. Rates of deformities of young-of-year frogs exceeded 10% at one site within the AOC. Contaminant body burdens or mercury, PCBs, and organochlorine pesticides were relatively low and were below guideline levels for the protection of fish eating wildlife. Testicular ovarian
follicles TOFs were found in the testes of some male frogs both within the AOC and upstream sites. Rates of TOFs were significantly higher in AOC sites, and were present in over 50% of frogs at some sites.

Keywords: Amphibians, Pollutants, St. Clair River.


Polybrominated diphenyl ethers (PBDEs) are lipophilic compounds that bioaccumulate through to the highest levels of the food chain. Many studies of PBDE concentrations have focused on fish-eating species of the aquatic food web, however eggs of wild peregrine falcons in Sweden contain among the highest concentrations of ΣPBDEs measured in wildlife. Eggs of American kestrels were collected from nest boxes from the Niagara region to southwestern Ontario. Subsequently, serum samples of sibling hatchlings were collected. Samples were analysed for 8 current-use flame retardants including dechlorane plus (DP). The PBDEs were the highest in total concentration in both egg and plasma, 0.6–15.2 ng/g and 0.08–1.1 ng/mL, respectively. BDE’s 47, 99, 100, 153, 154, 138 and 183 were detected in the eggs, however we did not detect BDE’s 138 and 183 in the plasma. Similarly, no BTBPE was detected in the plasma but measured in the eggs at 0.02–1.9 ng/g. Both the syn and anti stereoisomers of the chlorinated flame retardant, DP, were detected in eggs ranging from 0.01–0.25 ng/g. The highest egg concentration was measured in the Niagara region, nearest the manufacturer of DP. The spatial pattern for the plasma samples were similar, however only anti-DP was detected. Keywords: Polybrominated diphenyl ethers, Avian ecology, Terrestrial.

MASON, K. and EVANS, D.O. Golder Associates, 940-6th Ave. SW, Calgary, AB, T2P 3T1; Ontario Ministry of Natural Resources, Trent University, 2140 East Bank Dr., Peterborough, ON, K9J 7B8. The Influence of Predation by Crayfish on Over-wintering Lake Trout Eggs and Recruitment Success in Lake Simcoe.

Failure of natural recruitment of lake trout in Lake Simcoe during the past half century has been attributed to deteriorating water quality associated with intensive development of the watershed. Our objective was to evaluate an alternative hypothesis involving changes in the crayfish community and possible consequences for survival of over-wintering lake trout eggs. This hypothesis is not independent of water quality changes because of interactions between habitat quality, egg production and predation risk. In laboratory experiments we evaluated predation by the native crayfish Orconectes virilis, (OV) and the presumptive invader O. propinquus (OP). We also tested the influence of substrate depth and temperature for predation interaction effects with OV and OP. Field sampling determined lake wide distributions of OV and OP and densities at well known lake trout spawning sites. OP has largely displaced OV from preferred rocky habitats. In laboratory tests the much smaller OP was a superior egg predator, especially in deeper substrates and at colder temperatures. Modeling based on observed densities of OP at spawning sites, observed egg predation rates and known field temperatures, revealed that the entire egg deposition could potentially be consumed by OP within a few weeks after spawning. Keywords: Lake Simcoe, Lake trout, Recruitment.
MASSON, C., FreshWater Consulting, 341-2 Laird Dr., Toronto, ON, M4G 3T0. The Great Lakes Gordian Knot: Governance for Aquatic Ecosystem Health, Integrity, and Risk Management.

The Parties to the Boundary Waters Treaty of 1909 hold equal and similar usufructuary rights to the waters of the Great Lakes system; and therefore share management responsibilities for aquatic ecosystem health, integrity and risk in accordance with the 1987 Protocol to the GLWQA. Canada and the United States must act now to formalize a framework for agreement accountability, grounded in a public Statement of ethical principles and practices. The Boundary Waters regime is supported by large storage capacities and restricted outflows. The lakes are exhibiting symptoms of disturbance precluding a complete understanding of resilience. Concomitant loss of ecological goods, services and management options is encouraging a basin-wide evaluation of ecosystem integrity and socio-economic values. If ecosystem integrity is the ability to self-organise structurally when confronted with multiple stressors, then future Great Lakes ecology is uncertain, due to the potential tipping point to a less valued, weakly-integrated state. Managing multiple stresses requires flexible goals, stakeholder intervention guidance and appropriate uses of remaining lower quality resources so to avoid catastrophes and irreversible, negative effects. Unequivocal accountability for agreement implementation may sever this Great Lakes Gordian Knot of governance. Keywords: Governance, Great Lakes Water Quality Agreement, Ecosystem integrity.


The total areal extent of anoxic conditions within the central basin of Lake Erie was determined for the period between 1997 and 2007. Dissolved oxygen information from the U.S EPA, Great Lakes National Program Office and Environment Canada was used to generate a series of GIS maps based on the lowest integrated hypolimnetic dissolved oxygen concentration for each year. The total area affected by decreased oxygen levels ranged from 0% (2004) to 100% (2003) of the study area, with an average of 68% ±30 (S.D.). Annual hypolimnetic volume-corrected oxygen depletion (HVOD) rates ranged from 2.95 mg/L/mo to 4.10 mg/L/mo, and averaged 3.41 mg/L/mo ±0.32 (S.D.). Individual survey-based maps also illustrate the HVOD progression throughout the summer stratification season. Keywords: Anaerobic conditions, Lake Erie, GIS.

MAYER, A. 1, ZIMMERMAN, J. 2, MIHELCIC, J. 1, OLMSTEAD, S. 3, WATKINS, D. 1, and ZHANG, J. 1, 1Department of Geological & Mining Engineering & Sciences, Michigan Technological University, Houghton, MI; 2Environmental Engineering Program and School of Forestry & Environmental Studies, Yale University, New Haven, CT; 3Department of Civil and Environmental Engineering, Michigan Technological University, Houghton, MI. Modeling and Analyzing the Use, Efficiency, Value, and Governance of Water in the Great Lakes Region Through an Integrated Approach.
The objective of the proposed project is to determine the impact of direct and indirect drivers on water quality, quantity, and availability in the Great Lakes (GL) 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, including (1) development of modeling approaches to simulate quantity and quality in the GL region; (2) creation and testing empirical models of the energy embodied in water delivery and treatment for the GL context; (3) prescription of data and methods required for economic valuation of water resources in major sectors of water use in the GL basin; (4) identification of the most significant current and future withdrawals and consumptive uses of water in the basin; (5) collection of data on the prices, benefits, and costs of water consumption in major water use sectors; (6) estimates of opportunity costs to determine where water use minimization and elimination will have the most significant and sustainable benefits; and (7) identifying policy innovations to address vulnerabilities in the GL system under future scenarios.

Keywords: Regional analysis, Great Lakes basin, Model studies.

MCCULLOCH, R.D.1, DEKKER, T.J.1, BRADLEY, D.1, REDDER, T.M.1, LORD, B.D.1, and KUZIS, K.2, 1LimnoTech, 501 Avis Dr., Ann Arbor, MI, 48108; 2Environ, 3219 Camrose Lane, Boise, ID, 83706. Innovative Methods in Riverbank Stability Characterization: Classification of the Tittabawassee and Saginaw River Banks.

LimnoTech designed and conducted a bank classification survey of 44 miles of the Saginaw and Tittabawassee Rivers in Michigan to evaluate current bank stability and support the design and implementation, if appropriate, of stabilization technologies that may improve or promote long-term river bank stability. Surveys were designed to capture significant attributes, including degree of undercutting and mass wasting, vegetation and other surface cover, stabilizing structures, and physical characteristics such as surface material composition and bank geometry. Over 700 locations were surveyed using handheld GPS data recorders. In addition, continuous video was shot along both banks of the entire 44 miles of river. The video was linked to a GPS record to allow rapid, map-driven viewing of any point along the river banks. The data gathered in the survey will be combined with existing information on shear stresses imposed by daily and seasonal changes in river flow velocity, river geomorphology, land use and other factors. Survey results will be used to develop a system of scoring erosion potential of river banks. This can be used to extrapolate measurements of bank erosion rate to locations exhibiting similar bank characteristics and as a basis for identifying sites for application of bank stabilization technologies.

Keywords: Sediment transport, Watersheds, Great Lakes basin.

MCCULLOUGH, G.K.1, KLING, H.J.2, STAINTON, M.P.3, and BARBER, D.G.1, 1Centre for Earth Observation Science, Department of Geography, University of Manitoba, Winnipeg, MB, R3T 2N2; 2Algal Taxonomy and Ecology Inc., 31 Laval Dr., Winnipeg, MB; 3Canada Department of Fisheries and Oceans, Freshwater Institute, 501 University Crescent, Winnipeg, MB, R3T 2N6. Using Ship-borne Spectral Remote Sensing Reflectance Data to Compare Accuracy of Chlorophyll Determinations by
MODIS, MERIS, and VIIRS Satellite-borne Sensors over a Highly Eutrophic Lake, Lake Winnipeg, Manitoba, Canada.

Algal blooms have become of increasing concern to both users and managers of Lake Winnipeg. Chlorophyll (chl) concentrations frequently range up to 70 mg m\(^{-3}\) and are occasionally much higher in surface blooms. Remote sensing offers one means of mapping algal concentrations to monitor lakewide response to planned watershed management action. Here, we use shipborne remote sensing reflectance spectra collected on Lake Winnipeg to simulate MODIS, MERIS and VIIRS data to test algorithms for determination of chl. Blue/green band ratios traditionally used in chl mapping of Case I waters are very poor predictors of chl in the Case II waters characterizing Lake Winnipeg. MERIS MCI (maximum chl index) and FLH (fluorescence line height) are the best predictors of chl (r\(^2\)=0.84 & 0.75 respectively). MERIS FLH is less well-correlated with chl because in cyanobacteria the expected fluorescence peak at 685 nm is frequently overwhelmed by the combined effect of phycocerithrin absorption near 675 nm and “red edge” reflectance peak beginning near 700 nm. Consequently the correlation with chl in cyanobacteria is inverse, although it remains (weakly) positive in other algal assemblages. Chl in Lake Winnipeg is only weakly predicted by MODIS FLH (r\(^2\)=0.48) and less well by VIIRS band combinations tested. Keywords: Remote sensing, Phytoplankton, Cyanophyta.

MCDONALD, E.A.\(^1\), MCNAUGHT, A.S.\(^1\), and ROSEMAN, E.F.\(^2\), \(^1\)Department of Biology, Central Michigan University, Mount Pleasant, MI, 48859; \(^2\)U.S. Geological Survey, Great Lakes Science Center, Ann Arbor, MI, 48105. Susceptibility of Larval Fish to Entrainment in the Detroit River.

Industrial facilities that withdraw water from surface water bodies may also entrain larval fish. In some cases, data exist on the type and number of larval fish entrained by such facilities and those present in the source water body within the vicinity of the intake. Our objective was to evaluate if susceptibility to entrainment varied among species and over time. Entrainment samples were collected weekly during April-July 2006 from a facility with a cooling water intake on the Detroit River. Surface and bottom larval fish samples were collected with paired bongo nets (333 and 500 µm mesh sizes) at 2 sites near the facility and 7 additional sites in the Detroit River. An electivity index was used to compare relative abundance of each entrained species with relative abundance of that species in pooled river samples. Yellow perch were susceptible to entrainment, whereas white sucker, spottail shiners, and trout perch avoided entrainment. Lake whitefish were entrained at rates equal to their abundance in the river. Though abundant in the river, white bass and gizzard shad were absent from entrainment samples. Species-specific larval behavior, spatial distribution, and river current dynamics may drive susceptibility to entrainment in the Detroit River. Keywords: Fish behavior, Detroit River, Spatial distribution.

MCDONALD, K. and TONINGER, R., 5 Shoreham Dr., Downsview, ON, M3N1S4. Tommy Thompson Park – Toronto’s Urban Wilderness.

Tommy Thompson Park, also known as the Leslie Street Spit, is a man-made peninsula in east Toronto owned and managed by Toronto and Region Conservation. It was created to enhance port facilities and as a cost effective way to dispose of harbor dredgeate and construction materials. Through
natural succession processes the park has developed into one of the most significant natural features on the Toronto waterfront and has been designated as an Environmentally Significant Area and a globally significant Important Bird Area. Seeing more than 250,000 visitors annually, with exponential increases expected, the park has been adopted by the local ecological community and is an excellent case study of natural habitat in an urban context. The focus of TRCA’s work is planning, habitat restoration, and research to enhance and preserve this unique urban wilderness, while balancing human activity. Habitat projects, including wetland creation, reforestation, and meadow enhancements among many others, are ongoing and assist in the restoration of rare or significant plant and animal species. Ongoing collaborative research, including fisheries data as well as radio telemetry research on both coyotes and northern pike, indicate that the park is regionally significant and acts as a source, rather than a sink, for wildlife populations. Keywords: Urban areas, Management, Habitats.

MCDONELL, D.J.1, CREWE, T.L.2, MACKAY, S.3, COUTURIER, A.2, and MCCCRACKEN, J.2, 1Environment Canada, 867 Lakeshore Rd., Burlington, ON, L7R 4A6; 2Bird Studies Canada, 115 Front St., P.O. Box 160, Port Rowan, ON, N0E 1M0; 3University of Guelph, 50 Stone Rd. East, Guelph, ON, N1G 2W1. Demonstrating the Ecological Benefits of Habitat Restoration in the Canadian Areas of Concern Using Breeding Bird Atlas Data.

To date, the Canadian government has contributed in excess of $48,000,000 toward habitat restoration and rural pollution reduction projects that address environmental concerns in the Canadian Areas of Concern through the Government of Canada’s Great Lakes Sustainability Fund. This work has resulted in the restoration of over 3,640 ha of forests and wetlands (4,760 ha protected), 584 km of riparian habitat, 8 km of shoreline, 200 ha of tallgrass prairie and the mitigation of 27 fish barriers. An attempt to evaluate potential wildlife community changes at the landscape level was completed in 2007 using results from the Ontario Breeding Bird Atlas (collected over a 20 year span). Results from this preliminary study suggest that an increase in bird community richness (as indicated by metrics such as breeding bird community species richness across various guilds) in several AOCs over the past 20 years suggests that restoration efforts are having a positive impact on habitat quality and/or quantity. However, further work is required to distinguish whether the positive impacts observed were the result of a net increase in habitat and/or an increase in the quality of available habitat. Keywords: Assessments, Avian ecology, Biodiversity.

MCGAULEY, E.K., Trent University, 1600 West Bank Rd., Peterborough, ON. Wetlands that Work: A Comparative Assessment of the Ecological Potential of Treatment Wetlands Using Macroinvertebrate Indicators.

This study compared the macroinvertebrate diversity and environmental variables of a treatment wetland with natural wetlands to test the ecological potential of a municipal wastewater treatment wetland in Brighton, Ontario. Macroinvertebrate abundance data were collected by kick and sweep sampling and Hester-Dendy samplers. Environmental variables including depth, plant density, conductivity, total ammonia and dissolved oxygen were measured. Non-metric multi-dimensional scaling (NMDS) was used to explore the separation of macroinvertebrate communities with permutational analysis of variance.
substantiating ordinations. Natural wetlands had significantly different macroinvertebrate communities (p=0.001), at least twice the number of taxa, correspondingly high Simpson’s diversity indices, and twice the emergent plant density as treatment wetlands. Functional feeding group affiliations reflected differences between treatment and natural wetlands, with natural sites dominated by scrapers rather than the collectors found in treatment cells. Environmental variables were also significantly different (p=0.015), with higher dissolved oxygen concentrations in natural wetlands. Depth, conductivity, TKN, and total ammonia were all higher in treatment cells than in natural wetlands.

*Keywords: Macroinvertebrates, Assessments, Biodiversity.*

**MCLAUGHLIN, C.**, Dofasco Centre for Engineering & Public Policy, McMaster University, Hamilton, ON, L8S 4K1, Canada.  *Is Natural Resources Management in the Great Lakes Pathological?*

Traditional “command and control” approaches to natural resources management premised on an understanding of ecosystems as clearly defined and relatively simple aim for specific and expected outcomes such as harvest quotas or pollution abatement targets. A large-scale success of this kind is the initial response to measures taken under the 1972 Great Lakes Water Quality Agreement to reverse widespread ecological deterioration. The misapplication of these schemes to complex and poorly understood ecosystems often results, however, in human, institutional, or ecosystem behaviors that violate societal norms or expectations. Uncertainties inherent in ecosystems present added challenges for Great Lakes management because of deficiencies in the current governance structure. I evaluate evidence that Great Lakes management has suffered historically from what Holling and Meffe (1996) call a “pathology” using three characteristics of institutions exhibiting such pathological behavior suggested by Briggs (2003), that such institutions: instigate multiple, often incompatible planning processes; initiate new natural resource management programs repeatedly without evaluating the effectiveness of current or previous programs; and shed responsibility for capacity-building while developing closed cultures that suppress or resist ideas.

*Keywords: Policy making, Great Lakes basin, Ecosystems.*


The state of Michigan uses indicator bacteria including *E. coli*, total coliforms, and fecal coliforms to determine the safety of recreational waters, drinking water, and wastewater treatment, respectively. These indicators, however, do not identify the full extent of pathogen contamination or sources of contamination. Therefore, the use of alternative indicators, actual pathogen testing, and microbial source tracking have been used to identify sources and prevent further contamination of ground or surface waters. Our lab investigates watersheds across Michigan in order to better understand the inputs that affect the state and to identify more accurate alternative indicators. We used a combination of the previously noted tools to sample surface waters of the St. Marys River near Sault Saint Marie, Silver Lake, the Muskegon Waste Water Treatment Plant, Coldwater Creek near Freeport, and the Saginaw Bay. These sites were chosen and sampled in response to a water quality concern such as increased algal blooms, decreased water clarity, or exceeded effluent standard. The alternative indicator results identified
potential impacts that, given the use of only Michigan’s standard indicators, would not have been detected. ArcGIS software was used to map water quality sampling sites for several of these projects. 

Keywords: Water quality, Microbiological studies, GIS.


Current methods used for water quantity accounting and routing through the Great Lakes rely on empirically derived equations. As an alternative methodology, unsteady flow simulations using the HEC-RAS one-dimensional hydraulic model can be calibrated to compute discharges in the Great Lakes connecting channels. Recent changes to HEC-RAS have allowed the embedding of the Lake Superior regulation plan in the model. Modeling the lakes as storage areas with input time-series of water-balance data allows a practical meshing of hydraulic and hydrologic modeling for routing periods of up to 30 years. The different sequences of resulting lake levels and connecting channel flows, from simulations of alternative hydraulic characteristics or inflow data, are stored in the HEC-DSS format and can be easily compared to evaluate the effect of various study objectives. Since HEC-RAS and HEC-DSS are available for free and have existing large user bases, this ability may have wide application for many within the Great Lakes research community. Keywords: Model studies, St. Clair River, Lake management.

Meek, G.A.¹ and Crowe, A.S.², ¹School of Geography and Earth Sciences, McMaster University, Hamilton, ON, L8S 4M1; ²Environment Canada, Canada Centre for Inland Waters, Burlington, ON, L7R 4A6. Role of Groundwater-lake Interaction on E. coli Levels at Beaches of the Great Lakes.

E. coli, often at levels 1,000 times greater than found in nearshore lake-water, are frequently detected in groundwater below beaches within a few metres of the shore. Groundwater is a potential mechanism for delivery of E. coli to the shoreline and storage of E. coli here. Given the large numbers of septic systems at beach front residences, and that groundwater flow beneath beaches is toward the lake throughout the year, it is possible that septic system may be a source of E. coli. However, our studies provide no evidence that E. coli is migrating from septic systems via groundwater flow beneath beaches to the shoreline. Our field and modeling studies do indicate that the source of the high levels of E. coli found in the groundwater below the beach at the shoreline is the adjacent lake. During a storm, wave run-up across the shore causes lake water and associated E. coli to infiltrate to groundwater beneath the shore. The rapid infiltration raises the water table at the shore, causing a localized reversal in the direction of groundwater flow. This localized reversal restricts E. coli migration into the beach to several metres from the shoreline. A single storm event can cause large numbers of E. coli from the lake water to infiltrate into the subsurface at the shore and reproduce the observed levels of E. coli. Keywords: Coasts, Beaches, Water quality, Microbiological studies, E. coli.

Melymuk, L.E.¹, Robson, M.E.¹, Gilbert, B.², Helm, P.², and Diamond, M.L.¹, ¹University of Toronto, 45 St. George St., Toronto, ON, M5S 3G3; ²Ontario Ministry of the Environment, 125
Comparison of Chemical Profiles in Urban Rivers during Base Flow and Storm Events.

It is now widely acknowledged that large urban centers such as the Greater Toronto Area (GTA) are sources of a range of pollutants to the wider environment. One pathway through which this occurs is via the movement of pollutants into and through urban waterways. To investigate this aspect of contaminant transport and loadings to Lake Ontario, bulk stream water samples were collected from ten stream sites in the GTA, representing 6 watersheds with varying degrees of urban development. The samples were collected during base flow and storm events. Additionally, more detailed sampling was conducted over the course of the hydrograph at one urban and one suburban site, in order to better characterize chemical loadings during these events. Samples were analyzed for water quality indicators, including nutrients, chloride, and turbidity, as well as metals and persistent organic pollutants (POPs). A comparison of the trends across the different watersheds and differing land uses can provide insight into the factors and sources influencing the transport of metals and POPs through urban areas.

Keywords: Urban watersheds, Toxic substances, Tributaries.

Assessing Nearshore Small-fish Community Biodiversity in Lake Simcoe.

In 2006, the Ontario Ministry of Natural Resources, Lake Simcoe Fisheries Assessment Unit, began developing a sampling method to monitor small fish biodiversity in the nearshore zone of Lake Simcoe. This ongoing project seeks to assess trends in fish diversity through time. Long-term biodiversity monitoring of this kind will enable comprehensive reporting on the Lake Simcoe fish community. Additional objectives of this program include detecting the presence of new aquatic invasive species and measuring their impact on the fish community. Nearshore small fish sampling in 2006 and 2007 used multiple gear types to sample a range of nearshore habitats in Lake Simcoe. We will describe the diversity of the nearshore fish community, examine sampling effort levels required to adequately characterize the nearshore community, and compare the current state of nearshore diversity with assessments conducted 20 years prior. Preliminary results confirm the presence of many native and non-native fish species along Lake Simcoe’s shoreline, including the recently introduced round goby (Neogobius melanostomus), and suggest substantial changes in abundance of some cyprinid species may have occurred over the past 2 decades. Keywords: Biodiversity, Small fish, Lake Simcoe.

Automated Approach Using Definiens Developer 7.0 for Classification of Aquatic Vegetation in the Coastal Wetlands of Georgian Bay.

The pristine coastal wetlands of eastern Georgian Bay are under threat due to increased development. It is only possible to map these regions for conservation using remotely sensed data. Here we present a technique for classifying wetland coverage into open water, rock, and 4 vegetation classes.
using Definiens Developer 7 software. This software allows for a hierarchical analysis, grouping similar class types (vegetation) into larger regions and within these groups separate specific types (floating or emergent). Multiple iterations allow us to refine our classification to increase the accuracy. Work in our lab has shown that IKONOS satellite images can be used to map aquatic vegetation but previous techniques relied purely on differences in spectral signature and required extensive field data to train the computer. Although there is a large investment in time and money for the initial creation of the Definiens pathway, the final decision tree is easily applied to newly acquired images with minimal user input, essentially automating the process for end users. Automation allows us to quickly update our wetland inventory to include vegetation coverage information. Once a baseline is established for vegetation coverage, it will be easy to update our inventory and track changes which may occur due to fluctuating water levels. Keywords: Remote sensing, Georgian Bay, Coastal wetlands.

MIKODA, P.1, WESELOH, D.V.2, and PEKARIK, C.3, 1Canadian Wildlife Service-Ontario Region, Environment Canada, Canada Centre for Inland Waters, Box 5050, Burlington, ON, L7R 4A6; 2Canadian Wildlife Service-Ontario Region, Environment Canada, 4905 Dufferin St., Downsview, ON, M3H 5T4; 3Canadian Wildlife Service-Ontario Region, Environment Canada, 335 River Rd., Ottawa, ON, K1A 0H3. Satellite Tracking of Breeding Great Black-backed Gulls from Eastern Lake Ontario.

Recent increases in great black-backed gull (Larus marinus) (GBBG) nestings in eastern Lake Ontario over the last decade prompted us to examine their annual movements. In 2002, two adult GBBGs from different nests were captured on Pigeon Island (44.07, -76.55) and affixed with satellite transmitters. General migration patterns, breeding season, and overwintering locations and ranges as well as nocturnal movements were evaluated using these data. The birds’ general pattern of movement was to remain near the breeding colony from April until August, during which time Pigeon Island GBBGs consistently flew 40-45 km to the Bay of Quinte on what is assumed to be foraging trips. Interestingly, they were also making these trips at night, which is a new insight into the ecology of these birds. After breeding, the birds travel south to the Rochester, N.Y. area, where they stayed until late December. They then traveled to Niagara Falls for a week or two before continuing south-west to the Cleveland area to spend the remainder of the winter. Birds began heading back to the breeding colony in early March to arrive there for April. Both birds occupied similar, overlapping ranges during the winter of 2003. In the winter of 2004, the one remaining transmitting bird spent a good portion of time wintering in Sandusky, rather than Cleveland. Keywords: Avian ecology, Life history studies, Great Lakes basin.

MILFORD, L., BATES, S., and LANDRIAULT, L., Ministry of Natural Resources, Lands & Waters Branch 300 Water St. 5th Floor South, Peterborough, ON, K9J 8M5. A Tiered Water Budget Approach.

The Ontario government has introduced legislation to protect municipal drinking water supplies at the source through the Clean Water Act (2006). A tiered approach to the preparation of watershed-based water budgets has been developed and is currently being applied across the Province. The key objective of the water budget is to provide an understanding of the water supply, demand and consumptive uses. The framework for the tiered approach to water budget consists of four levels; the first level a “Conceptual
Understanding” is followed by an additional three tiers which may range in scale from a broad watershed level down to a localized area around a municipal water intake. Each tier involves a more detailed analysis of the interaction between groundwater and surface water resources which increases certainty. The tier of water budget analysis required in each of the watershed areas is dependent on a level of stress based on the relationship between supply and demand and a water reserve. This presentation will highlight on-going watershed-based water budget work and will demonstrate how the tiered approach has been applied to specific regions. **Keywords:** Drinking water, Watersheds, Water budget.


Bioinvasion modes are interlinked with industrialization and human population growth. The situation in the Laurentian Great Lakes area started to deteriorate in the 19th century, with construction of canals and the St. Lawrence Seaway some 50 years ago. One of the most successful transatlantic invaders to the Great Lakes is the Eurasian round goby, *Neogobius melanostomus*, native to the Black Sea and the Sea of Azov. The round goby is supposed to have travelled via contaminated ballast waters of tankers due to its ability to survive extremely degraded water quality. Nevertheless, the situation in Europe is similarly crucial as for decades it is spreading throughout Europe as well. Variations of several meristic values highlight its adaptation speed to a non-native habitat, possibly also accounting for building of sub-populations. Studies on European populations of *N. melanostomus* show that the original populations possess very high intraspecific variation potential and high morphological plasticity. Our recent studies on morphological features – such as fin ray counts and scalation – of over 450 individuals do not result in the same findings. Moreover, we detected meristical variations comparing alien Canadian and U.S. populations. **Keywords:** Biological invasions, Neogobius melanostomus, Round goby, Morphological variation, Invasive species, Black Sea.

MILLER, B.1, FACKLER, J.1, MANKIN, P.1, HORVATIN, P.J.2, ANDREN, A.3, and BRANDT, S.B.4, 11101 W. Peabody Dr., 350 National Soybean Research Center, MC-635, Urbana, IL, 61801; 277 W. Jackson Blvd. (G-17J), Chicago, IL, 60604-3511; 31975 Willow Dr., Madison, WI, 53706-1177; 42205 Commonwealth Blvd., Ann Arbor, MI, 48105-2945. **Great Lakes Regional Research Information Network - Lake Michigan.**

NOAA requested regional development plans for U.S. coastal, ocean, and Great Lakes areas. The Great Lakes Regional Research Information Network (GLRRIN) is developing a comprehensive research and information plan that will help focus research, technology transfer, and outreach efforts on the highest priority issues within the Great Lakes region. The Network consists of five teams, each focusing on one of the Great Lakes. The Lake Michigan team compiled a comprehensive list of organizations with a strong interest in Lake Michigan. The results indicate that ecosystem, pollutants, education, aquatic invasive species, and water issues were the top five priorities for the majority of the organizations. The Lake Michigan team concluded that specific research projects needed to address problems in the topic areas are
dynamic and are expected to change frequently as new discoveries are made and new problems arise. Further coordination among the agencies and institutions sponsoring and conducting research is needed to prioritize specific research questions and distribute agency attention and resources to these questions as conditions change. The implementation phase of this project will engage scientists and funders in finding solutions to our Lake Michigan priority research issues. **Keywords:** Data acquisition, Decision making, Lake Michigan.

**MILLIGAN, M.S.**<sup>1</sup>, **KROON, B.**<sup>1</sup>, **ORCHARD, A.**<sup>1</sup>, **HOLSEN, T.M.**<sup>2</sup>, **CRIMMINS, B.**<sup>2</sup>, **PAGANO, J.J.**<sup>3</sup>, and **SUMNER, G.**<sup>3</sup>,  1SUNY Fredonia, Fredonia, NY, 14063;  2Clarkson University, Potsdam, NY, 13699;  3SUNY Oswego, Oswego, NY, 13126. **Analysis of PCDD/F and WHO Coplanar PCBs in Great Lakes Fish.**

As part of the Great Lakes Fish Monitoring Program, we are analyzing whole fish composites and fish fillets collected at different sites from all five of the Great Lakes for a suite of contaminants such as Hg, PCBs, organochlorine pesticides, PBDEs, and PCDD/Fs. In this contribution, we will report on fish concentrations of PCDD/F homologues and the twelve coplanar PCBs designated by the World Health Organization (WHO). Five gram fish homogenates are extracted using Accelerated Solvent Extraction (ASE), followed by preliminary clean-up using automated gel permeation chromatography. After multi-layer silica column clean-up, PCDD/Fs and coplanar PCBs are isolated using dual-layer carbon column fractionation. The final extracts are then analyzed using gas chromatography/mass spectrometry. As an example, 2004 Lake Michigan Trout (n = 8) were measured to have an average of 231 ± 61 ng/g of WHO coplanar PCBs, with the most abundant congeners being PCB-118 > PCB-105 > PCB-123 > PCB-156. Average total PCDD/F for these same samples were measured to be 6.9 ± 1.4 ng/g, whose homologue pattern was dominated by the lower chlorinated dibenzofurans (tetra- and penta-). Additional results will be presented for fish tissue collected from all five Great Lakes. **Keywords:** Environmental contaminants, PCBs, Fish toxins.

**MINNS, C.K.**<sup>1</sup>, **SHUTER, B.J.**<sup>2</sup>, and **TRUMPICKAS, J.**<sup>2</sup>,  1Bayfield Institute (GLLFAS)(DFO), PO Box 5050, 867 Lakeshore Road, Burlington, ON, L7R 4A6;  2Harkness Laboratory of Fisheries Research (OMNR), 300 Water St., Peterborough, ON, K9J 8M5. **Modeling Great Lakes Surface Temperatures and Predicting Future Values with Climate Change.**

The strength of monitoring programs lies in their consistency, duration, and how their results are used. The last feature is often neglected. Surface water temperature is routinely monitored around the Great Lakes via water intakes, index sites, synoptic surveys, and remote sensing. Temperature is a key factor in biological productivity, particularly of fisheries, and sets the rate of many ecosystem processes. During open water, surface temperature typically exhibits a linear warming through the spring, rising to a peak mid-summer, followed by a linear cooling into the fall. Analyses of lake-wide and area means, and intake temperatures around the Great Lakes, indicate the warming and cooling rates vary little by location while the peak values vary among years. The timing of the peak varies little. Hence, by location, the length of the growing season and the maximum summer surface temperature are strongly linked. Location characteristics strongly influence warming and cooling rates while peak temperatures are linked to
climate. Predictions of climate change from the Canadian CGMC2 model under different scenarios are used to estimate future surface temperatures. Substantial temperature increases maybe expected with consequences for ecosystem processes and fisheries. The implications for future monitoring are assessed. **Keywords:** Climate change, Great Lakes basin, Ecosystem modeling.

MOLOT, L.A.¹, LI, G.², FINDLAY, D.L.³, and WATSON, S.B.⁴, ¹Faculty of Environmental Studies, York University, 4700 Keele St., Toronto, ON, M3J 1P3; ²Dept. of Geography, York University, 4700 Keele St., Toronto, ON, M3J 1P3; ³Freshwater Institute, Canadian Department of Fisheries and Oceans, 501 University Crescent, Winnipeg, MB, R3T 2N6; ⁴National Water Research Institute, Environment Canada, PO Box 5050, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Iron Regulation of Bloom Forming Cyanobacteria Abundance.**

Blooms of toxic cyanobacteria remain a global problem in lakes and rivers receiving excessive amounts of nutrients despite major investments in phosphorus control strategies in many countries. While numerous hypotheses have been advanced, there is no clear understanding of why these cyanobacteria typically dominate productive, nutrient-rich (eutrophic) waters or why they are rare in unproductive, low-nutrient (oligotrophic) waters where biological productivity is usually limited by low levels of phosphorus. An experiment in fertilized Lake 227 in the Experimental Lakes Area in northwestern Ontario showed that formation of a cyanobacterial bloom was prevented by reducing access to ferrous iron despite elevated concentrations of other forms of iron. It appears that iron-limitation explains their absence in oligotrophic waters because of typically low ferrous supply rates. Work is ongoing in Hamilton Harbour in Lake Ontario to assess the relationship of blooms in these waters to the bioavailability of iron. The ferrous iron limitation model has major implications for improved control of harmful cyanobacterial blooms in eutrophic waters. **Keywords:** Cyanophyta, Iron, Phytoplankton.

MONTGOMERY, K.E. and FREEMAN, A.D., 5 Shoreham Dr., Downsview, ON, M3N 1S4. **Aligning Remedial Action Plans with Watershed Plans, Is It a Good Idea?**

The Toronto and Region Remedial Action Plan (TORRAP) has always adopted a watershed based approach. With its size, complexity of governance and the 3 million plus people living in this fast growing area, the ultimate success of this RAP will be no small feat. A lot has changed since the Stage 1 Report (1988) defined this Area of Concern to include the waterfront and the adjacent drainage basins. In 1988, watershed planning was in its early stages, the State of the Ecosystem for the Don River Watershed (1992) was the first move toward planning at a scale appropriate to improve environmental conditions in this region. Plans for each of the watersheds within Area of Concern have been developed and now, the next evolution in watershed planning, integrated watershed management is on-going. The RAP program focuses on the endpoint with the objective of working on a problem, fixing it so that the action can be completed. This process lends itself best to dealing with point source problems, whereas the issues impacting this region stem from non-point sources; often there is no clear-cut fix and the solution is continual vigilance. The question remains for the TORRAP: how to best work within the RAP program, with its push for “delisting,” when we are dealing with issues that do not have short-term solutions? **Keywords:** Urban areas, Urban watersheds, Toronto and Region Remedial Action Plan.
MOORE, D.J.¹, WESELOH, D.V.², and PEKARIK, C.¹, ¹Canadian Wildlife Service-Ontario Region, 867 Lakeshore Rd., P.O. Box 5050, Burlington, ON, L7R 4A6; ²Canadian Wildlife Service-Ontario Region, 4905 Dufferin St., Downsview, ON, M3H 5T4. **Competition within Tree- and Ground-nesting Guilds and Serial Replacement of Species at Great Lakes Waterbird Colonies.**

We use historical changes in colonial waterbird numbers and nest distributions at Hamilton Harbour, ON (HH) as a case study to examine whether breeding colonies pass through predictable successional stages. The pattern of serial replacement of ground nesting species, repeated at a number of sites within HH, was as follows: (1) common terns, (2) ring-billed gulls, (3) herring gulls, and (4) double-crested cormorants (DCCOs). For tree nesting species, the following temporal patterns have been observed repeatedly: (1) colonization by black-crowned night-herons (BCNHs), (2) reduced BCNH nest heights as DCCO density increased, (3) movement of BCNHs to smaller trees and shrubs, (4) abandonment of the site by BCNHs, and (5) increased ground nesting by DCCOs as nest trees die. The observed patterns are likely driven by competition for nesting space (within tree- and ground nesting guilds) and changes in plant community structure, brought about, in part, by the nesting activity of the various birds. We present data on nest-site competition among tree-nesting herons, egrets, BCNHs and DCCOs and review evidence for competition among ground-nesting species. These natural processes have important implications for waterbird management and conservation. **Keywords: Avian ecology, Species diversity, Biodiversity.**

MORBÉ, Y.E.¹, ANDERSON, D.M.¹, and HENDERSON, B.A.¹, ¹Aquatic Research and Development, Owen Sound, ON, N4K2Z1; ²University of Western Ontario, London, ON, N5A5B7. **Progress Toward the Rehabilitation of Lake Trout (Salvelinus namaycush) in South Bay, Lake Huron.**

We evaluated the status of lake trout Salvelinus namaycush rehabilitation in South Bay, Lake Huron from 2001-2006. Standardized surveys were conducted to quantify natural recruitment, annual mortality, and the contribution of wild- versus hatchery-origin lake trout. Some indicators suggest a high level of natural recruitment. The spawning population was comprised of multiple ages, and the mean age of spawners (8.4 years for females, 7.9 years for males) was at least one year older than the estimated age at 50% maturity (5.8 years). Estimated annual total mortality rates (0.20 – 0.25) and sea-lamprey induced mortality rates (0.02) were less than maximum allowable values. Finally, the proportion of wild-origin fish captured was high among spawners (42%-88%, depending on the survey method). A strong year class (1997) could be tracked from 2001 to 2005, with few fish captured from earlier or later year classes. We speculate on reasons for low natural recruitment from the 1999-2001 year classes. **Keywords: Fish populations, Lake Huron, Lake trout.**

MUIR, D.C.G.¹, HOWARD, P.², and SMITH, E.³, ¹Aquatic Ecosystem Protection Research Division, Environment Canada, Burlington, ON, L7R 4A6; ²Syracuse Research Corporation, 301 Plainfield Rd., Suite 350, Syracuse, NY, 13212; ³U.S. Environmental Protection Agency, 77 W. Jackson Blvd., Chicago,

Tens of thousands of chemicals are used commercially in the United States, Canada, and other countries of the world. Frequently, the chemicals that become environmental contaminants and PBT chemicals are only detected after decades of commercial use. Part of the reason for this is that analytical chemists often find it difficult to detect chemicals that they are not anticipating. This project provides analytical chemists with a prioritized list of chemicals for which to develop new analytical methods. The toxicity of the priority list is also being assessed. This project screened high and medium production substances from a combined Canadian Domestic Substances List and the U.S. TSCA Inventory for P, B, and T characteristics. A short list of substances was developed and analyzed for available methods.

Keywords: Monitoring, Great Lakes basin, PBTs.

MUIR, T.A., Environment Canada - Retired, 70 Townsend Ave., Burlington, ON, L7T 1Y7. On the Need for Health Indicators for the Great Lakes Water Quality Agreement.

Annex 11 of the Great Lakes Water Quality Agreement calls for health indicators to help evaluate the achievement of Annex 1 Specific Objectives, including, the virtual elimination of PTSs, and consideration of interactive toxic effects of combinations of substances on aquatic, animal or human life. No PTS has been virtually eliminated, and new ones are on the rise. Wildlife and humans mirror a variety of endocrine, metabolic, reproductive, developmental, and cancer effects, suggesting relevant indicators. Monitoring is on trends in pollutant concentrations, but no formalized monitoring program of such health indicators exists. Instead, the Parties use risk assessment comparing exposure estimates to toxicological model effects levels for single substances. However, emerging evidence indicates that binary and complex mixtures are most often at least dose additive. There are discordant results between toxicological studies and epidemiology, including some animal experiments. Toxicology often shows a large margin of exposure between experimental model effects and human exposure (e.g., uM compared to nM). Epidemiological models may report significant effects in humans at real-world exposures or body burdens of nM levels. Mixtures, susceptibility, and discordance challenge the Parties to develop health indicators for the real world.

Keywords: Human health, Environmental health, Risk assessment.

Pharmaceuticals and Personal Care Products (PPCPs), Hormones, and Alkylphenol Ethoxylates (APEs) in the North Shore Channel of the Chicago River - Part 1: Concentrations in Fish Tissue and Analysis of Reproductive Impairment.

U.S. EPA's Great Lakes National Program Office (GLNPO) developed a study on the North Shore Channel to supplement the U.S. EPA’s Office of Water’s national study of PPCPs in fish tissue that is determining the occurrence of 39 PPCPs in composited fish fillets and liver samples from five sites (plus one reference site) where waters are dominated by waste water treatment plant (WWTP) effluents. The supplemental study on the North Shore Channel is a collaborative partnership between several Federal Agencies, Universities, and City Departments to (1) determine if there is reproductive impairment to resident fish and (2) document seasonal differences in concentrations of these compounds in fish. Preliminary results suggest that some male fish do have measurable levels of vitellogenin (vtg) but that no intersex or other severe pathological conditions were found at reference or regular collection sites. Additional results to be shared include measured concentrations of Nonyl & Octyl Phenol Ethoxylates and selected PPCPs as they relate to seasonal variability and comparison of these compounds between supplemental study samples and the national study samples. Keywords: PPCPs, Fish Reproduction, Wastewater.

Seasonal and Interannual Variation in Growth Rates of Pumpkinseed and Largemouth Bass in Lake Ontario Embayments.

In this study, which focuses on young of the year largemouth bass and pumpkinseed along the northwest shoreline of Lake Ontario, we report how seasonal and interannual growth rates vary between embayments and contrast their observed end of season growth with published growth rates of largemouth bass and pumpkinseed in nearby smaller inland lakes. We have found that unlike other largemouth bass populations, those that reside in embayments are not switching to piscivory in their first year of life and pumpkinseed growth is stunted; both of which may be possible symptoms of pressures reducing their early growth that are created by residing in an embayment connected to a large cold water body. Thermal regimes, diet, food availability, and sediment contamination are critically examined to try and explain these unusual findings. Keywords: Wetlands, Lake Ontario, Fish diets.

Stopping the Next Zebra Mussel: 20 Years Later, Policy Gaps Remain.

The zebra mussel invasion led to significant changes in legislation and policies managing ballast water of ocean vessels in the United States and Canada. However 20 years after the invasion, existing regulations still would not have been effective in stopping the zebra mussel from establishing. Recent crises associated with the VHS virus raise new concerns with ensuring ballast is not a vector for viruses and pathogens. And recent research has raised the profile of hulls as a possible source of invasive species. This session will focus on the current status of pending ballast water legislation, whether it will stop the
next zebra mussel and how far it goes addressing recent developments surrounding viruses and hulls. Additional issues to be discussed include controversies associated with state versus federal rights and Coast Guard versus Environmental Protection Agency leadership, as well as setting regulations for coastal and laker voyages between the United States and Canada. Keywords: Ballast, Dreissena, Policy making.


Just a few years after *Dreissena* (zebra and quagga mussel) first became established and rapidly increased in North America, it became obvious that these organisms would have a profound impact on the Great Lakes ecosystem. Some impacts were immediate and may have been predicted from the European literature, such as an increase in water clarity, a decrease in phytoplankton, and the loss of native mussels. Even so, achieved population densities led to changes that far exceeded expectations. Some impacts took longer to recognize and were mostly unpredicted. Examples include the complete disappearance of the amphipod *Diporeia* spp., an increase in blooms of *Microcystis*, and the extensive growth of nearshore mats of *Cladophora*. Dreissenids have been indirectly implicated in the return of *Hexagenia* to western Lake Erie, the expansion of the central Lake Erie hypoxic zone, and an increase in avian botulism, but research is needed or is underway to fully develop these relationships. One of the greatest unexpected surprises was the population expansion and high densities of quagga mussel “profunda” in deeper waters of many of the lakes. As a result, dreissenid impacts on the Great Lakes ecosystem are still evolving, and ultimate consequences have yet to be realized. Keywords: Zebra mussels, Zoobenthos, Dreissena.


River network structure is emerging as a possible important determinant of habitat and population dynamics for many riverine species. Adult sea lamprey (*Petromyzon marinus*) base movement decisions during their upstream spawning runs on the concentration of a larval pheromone and the relative sizes of confluent tributaries. As a result, spatial patterns of sea lamprey distribution within a watershed exhibit hallmarks of a complex adaptive system that depends on the structure of the river network. We used a simple individual based model to test the hypothesis that lamprey aggregation is positively correlated with river network diameter. Model predictions are consistent with the hypothesis. We also used the model to explore outcomes from management scenarios, including dam removal to restore stream habitat and pheromone release for lamprey control. We discuss our progress in using larval density patterns from routine field assessments to validate the outcomes of our model, and how our hypotheses may complement existing knowledge of in-stream sea lamprey dynamics. Keywords: Sea lamprey, Individual based model, River network structure.
NEESON, T.M., ADLERSTEIN, S.A., and WILEY, M.J., School of Natural Resources and Environment, University of Michigan, 440 Church St., Ann Arbor, MI, 48109. **Regression Tree Modeling of Sea Lamprey Ammocoete Habitat in Michigan Rivers.**

The habitat of sea lamprey (*Petromyzon marinus*) ammocoetes is well defined by substrate preferences, and the amount of suitable habitat plays a central role in estimating larval abundance and ranking streams for annual lampricide control. Riverscapes and sediment transport are controlled by multiple processes with potential thresholds and complicated interactions, with the result that they may be difficult to model with linear regression. We used regression trees to build predictive models of sea lamprey ammocoete habitat for rivers in Michigan’s lower peninsula. We used substrate data (~6,000 transects) collected during routine larval assessment surveys and GIS-derived variables stream power, riparian corridor surficial geology and land use, and low flow yield. We constructed three regression trees, with splits based on 1) latitude and longitude, 2) the fitted regression response, and 3) both latitude/longitude and fitted regression response. Inferring causal relationships from the final trees was difficult. We discuss the extent to which our tree splits match published ecoregions and the functional forms of causal geomorphic relationships. **Keywords: Habitats, GIS, Spatial distribution.**

NEKOUEE, N.¹, ROBERTS, P.¹, SCHWAB, D.J.², and MCCORMICK, M.J.², ¹School of Civil Engineering, Georgia Institute of Technology, Atlanta, GA, 30332; ²NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 48105. **3D Numerical Prediction of the Grand River Plume.**

The nearshore behavior of the Grand River plume as it enters Lake Michigan is modeled in three dimensions. Simulation of the mixing and transport mechanisms in the near field and transition to far field is of particular concern. Far field models typically incorporate grid sizes that are larger than the scale of near field processes by orders of magnitude. Hence, predictive capability is usually sought by refining the far field model grid size or coupling the far field model with a near field model. In this study, the Princeton Ocean Model (POM) is used to simulate the dispersion of the Grand River plume near the local beaches with a grid size of 100 m in a 24 x 6 km domain. The open water boundary conditions are obtained from a whole-lake hydrodynamic simulation with a 2 km grid resolution. The model predictions are compared with extensive the field observations to determine the extent to which the model can simulate the near field processes and hence the need for either further refining the model grid or coupling it with a separate near field model. The results of this research will improve numerical modeling of nearshore water quality. **Keywords: Hydrodynamics, Human health, Computer models.**

NELSON, W.H.¹, POULTON, N.J.², and PETERSON, K.A.¹, ¹Fluid Imaging Technologies, 65 Forest Falls Dr., Yarmouth, ME, 4096, USA; ²Bigelow Laboratory for Ocean Sciences, Boothbay Harbor, ME, 4575, USA. **An Evaluation of Viability Assays Using a Continuous Imaging Particle Analyzer (FlowCAM®) for Ballast Water Analysis and Regulatory Compliance.**

The FlowCAM®, an imaging particle analyzer, is an instrument used for rapid plankton detection and analysis, with the ability to detect auto-fluorescence (chlorophyll) or stain-induced-fluorescence in organisms. The fluorescence is used as a “trigger” for a camera to capture images of target organisms.
within a sample. The FlowCAM adds a unique capability to the ballast water monitoring process by using different stains to determine the viability of organisms in ballast water. Compared to traditional microscopic methods which are laborious and plagued by operator error, the value of FlowCAM lies in the immediate feedback the user receives with regard to viability. We present results of different viability assays using the FlowCAM, using both fluorescent and visual stains, in order to determine how effective these assays are at detecting viable organisms in ballast water. Keywords: Invasive species, Phytoplankton, Biological invasions.

NGHIEM, S.V.¹ and LESHKEVICH, G.², ¹JPL/California Institute of Technology, 4800 Oak Grove Dr., Pasadena, CA, 91109; ²NOAA/Great Lakes Environmental Research Laboratory, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105. Using Satellite Scatterometer Data to Map and Monitor Variations in Great Lakes Ice Cover.

Ice cover in the Great Lakes has a major impact on commerce and public safety, and is a sensitive index of regional winter climate. Recent studies, based on observed annual maximum ice cover (AMIC) from 1963 to 2002, found it was at a maximum of 97.4% in 1979 and a minimum of 14.8% in 2002. Winter 2002 set a new record low AMIC, while during winter 2003, three of the Great Lakes froze over for the first time in nearly a decade. The large spatial and high temporal coverage of satellite scatterometer measurements with its all-weather, day/night sensing capabilities make it well suited to map and monitor Great Lakes ice cover to extend the historical climatological record. The SeaWinds scatterometer (Ku-band) on the QuikSCAT satellite (QSCAT) has been collecting backscatter data over the world continuously since its launch in June 1999 and can cover most of the Great Lakes two times per day. Results of ice cover freeze-up and break-up dates observed by QSCAT over large lakes in North America and Europe show similarity between ice cover response and indicate that ice freezeup date, breakup date, and ice cover duration are appropriate integrated indicators of climatic conditions over the hemispheric scale. Keywords: Remote sensing, Ice, Monitoring.

NGUYEN, V.T. and LAMB, K.G., Department of Applied Mathematics, University of Waterloo, Waterloo, ON, N2L 3G1. Numerical Simulation of Nonlinear Internal Waves Generated by Wind Forcing over a Surface of Lake Erie.

Wind blowing over a lake surface transfers mechanical energy to basin-scale motions from which it cascades to the smallest scales of motion in a stratified lake. These motions include basin-scale internal waves driven by temporal variations in wind stress and basin-scale mean circulation driven by spatial variations in wind stress. The internal waves are responsible for redistribution of nutrients, pollutants, and sediments. Since basin-scale internal waves are the predominant source of energy for small scale internal wave, the correct modeling of lake mixing and transport requires accurate modeling of basin-scale internal waves. Modeling of basin-scale internal waves using three-dimensional hydrostatic models has been carried out by many authors. Nonlinearity results in the transfer of some of the energy in basin-scale waves to high frequency, nonlinear, nonhydrostatic waves. This transfer and consequential shoaling and breaking cannot be modeled with a hydrostatic model. In this study, a fully nonhydrostatic, three-dimensional model, the MIT general circulation model (MITgcm) (Marshall et al. 1997) is used to
simulate the basin-scale internal waves generated by wind-induced forcing on the surface of the Lake Erie. *Keywords: Lake Erie, Waves, Mathematical models, Basin-scale internal waves.*

O’DONNELL, D.M.\(^1\), QUARING, G.F.\(^1\), SPADA, M.E.\(^1\), STRAIT, C.M.\(^1\), EFFLER, S.W.\(^1\), and LESHKEVICH, G.\(^2\). \(^1\)Upstate Freshwater Institute, P.O. Box 506, Syracuse, NY, 13214; \(^2\)Great Lakes Environmental Research Laboratory, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105. *Spectral Measurements of Absorption, Beam Attenuation, and Backscattering Coefficients, and Remote Sensing Reflectance in Lake Ontario and Lake Erie.*

An optics survey of Lake Ontario (August 2007) and Lake Erie (September 2007) was conducted to characterize the underwater light field and the coupled water-leaving optical signal. Instrumentation measurements at 7 sites in Lake Ontario and 14 sites in the central and western basins of Lake Erie included: (1) Spectral absorption, beam attenuation, and backscattering coefficients \([a(\lambda), c(\lambda), and b_b(\lambda)]\) measured with WETLabs® ac-s and BB9 meters; scattering coefficient \([b(\lambda)]\) obtained by difference \([c(\lambda)-a(\lambda)]\), and (2) upwelling radiance and incident irradiance measured with a Satlantic® HyperPro II. Spectral and vertical patterns of \([a(\lambda), c(\lambda), b(\lambda), and b_b(\lambda)]\) are reported. Scattering represented between 60% - 90% of \(c\) at \(\lambda=440\) nm. Optical characteristics of a “whiting event” and Deep Chlorophyll Layers (DCL) observed at several sites in Lake Ontario are presented. 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 \(R_{rs}(\lambda)\) on \(b_b(\lambda)\) and \(a(\lambda)\). *Keywords: Underwater optics, Remote sensing, Remote sensing ground-truth.*

O’DONNELL, D.M.\(^1\), QUARING, G.F.\(^1\), SPADA, M.E.\(^1\), EFFLER, S.W.\(^1\), and LESHKEVICH, G.\(^2\). \(^1\)Upstate Freshwater Institute, P.O. Box 506, Syracuse, NY, 13214; \(^2\)Great Lakes Environmental Research Laboratory, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105. *An Optics Survey of the Western Basin of Lake Erie.*

An optics survey of the western basin of Lake Erie was conducted over a three day interval in September 2007, following a major wind event, to characterize the underwater light field and the coupled water-leaving optical signal. Instrumentation measurements at 14 sites included: (1) Spectral absorption, beam attenuation, and backscattering coefficients \([a(\lambda), c(\lambda), and b_b(\lambda)]\) measured with WETLabs® ac-s and BB9 meters; scattering coefficient \([b(\lambda)]\) obtained by difference \([c(\lambda)-a(\lambda)]\), and (2) upwelling radiance and incident irradiance measured with a Satlantic® HyperPro II. Salient findings and observations presented include: (1) strong spatial differences in concentrations of light attenuating constituents and the measured optical properties, (2) good closure between laboratory and field measurements of \(a(\lambda)\), (3) spectral characteristics of \(a\), components of \(a, c, b\), and normalized water leaving radiance \(L_{wn}\), (4) strong positive linear dependence of the backscattering ratio \((b_{bp}/b_p)\) on the fraction of suspended solids that is inorganic, and (5) good consistency between HyperPro II and MODIS (Aqua spacecraft, EOS PM-1) measurements of \(L_{wn}\). *Keywords: Underwater optics, Remote sensing, Lake Erie.*
O’NEILL, C.R., Morgan II, State University College, Brockport, NY, 14420. **Operational and Economic Impacts of Zebra Mussels on Great Lakes Water-Dependent Infrastructure.**

Since the 1989 discovery of zebra mussels (*Dreissena polymorpha*) in Lake St. Clair, the mussel and its congener *D. bugensis* (the quagga mussel) have had profound affects on the biological, physical, chemical, and hydrological properties of the Great Lakes. Dreissenid mussels have also had significant impacts on major water-dependent infrastructure. This paper will provide an overview of the physical (operational) and economic impacts of dreissenids on Great Lakes infrastructure. Dreissenids impact the water handling systems of such major infrastructure as electric power generation, drinking water treatment and industrial facilities from the mouths of intakes, through all internal water distribution components, to any discharges back into surface waters. Physical impacts include head loss and reduced water flow and clogging of components. Economic impacts include lost production, damaged components, employee time and effort expended unblocking and cleaning fouled systems, facility retrofit and long-term fouling prevention and control activities. Economic impacts on infrastructure from 1989 through the present will be discussed referencing the 1995 study by the National Aquatic Nuisance Species Clearinghouse and the 2005 NY Sea Grant/Cornell University study. **Keywords:** Zebra mussels, Impaired water use, Economic impact.

OBUSHENKO, N.¹, REID, K.B.², and NUDDS, T.¹, ¹Department of Integrative Biology, University of Guelph, Guelph, ON, N1G 2W1; ²Ontario Commercial Fisheries’ Association, 45 James St., Blenheim, ON, N0P 1AO. **Risk Assessment of Alternative Initial Allocations of Lake Erie Walleye Using Catch at Age Simulation and a Bayesian Approach to Uncertain Stock-recruit Dynamics.**

Initial allocations of walleye quota to the Ontario commercial fishery occur in January each year, which permits a limited harvest until May when the final total allowable catch is set. A catch at age model with discrete time simulated population dynamics and catch was used to evaluate risk associated with various initial allocation decisions. Bayesian methods were used to analyze uncertainty in the stock-recruit relationship. An extended Ricker function with a log-normally distributed error term described recruitment to the population. At low fishing mortality rates (i.e., less then 0.2), there was little difference in risk of stock collapse for initial allocations ranging from 5% to 50% of the total allowable catch. At higher rates of fishing mortality (0.3), risk of walleye fishery collapse increased marginally from 0.8% when the initial allocation was 10%, to 1.8% when the initial allocation was 50%, of the TAC. Our result is consistent with a view that there may be more capacity in the walleye population to withstand reasonable initial allocations than has been assumed. Armed with it, managers might more confidently go forward with an active adaptive management approach to setting initial allocations. **Keywords:** Fisheries, Walleye, Risk assessment.

OLSON, A. and FREELAND, J.R., Department of Biology, Trent University, Peterborough, ON, K9J 7B8. **Hybridization Facilitates Cattail Invasions around the Great Lakes.**

During the past two centuries, invasive species have substantially changed the Great Lakes ecosystem. Rapidly growing invasive plant species in the Great Lakes area include cattails (*Typha* spp.),
which in some areas are posing a significant threat to biodiversity and ecosystem function. While environmental change has undoubtedly influenced the recent expansion, it is also possible that hybridization has increased the ecological tolerance of *T. x. glauca*, a purported hybrid of native (*T. latifolia*) and invasive (*T. angustifolia*) cattails. In order to assess the invasiveness of *T. x glauca* relative to its parental species, we have 1) surveyed the range of habitat types that the three taxonomic groups favor, and 2) used genetic data to determine whether *T. x glauca* exists only as first generation (F1) individuals, or has now become evolutionarily distinct from its parental species. Our results provide important insights into some of the processes behind the invasion of cattail populations.

**Keywords:** Invasive species, Habitats, Marshes.

ONI, S.K.¹, OUELLETTE, J.C.¹, FUTTER, M.N.², and DILLON, P.J.³ ¹Watershed Ecosystem Graduate Program, Trent University, Peterborough, ON, K9J 7B8, Canada; ²The Macaulay Institute, Aberdeen, AB15 8QH, United Kingdom; ³Department of Environmental Science and Resource Studies, Trent University, Peterborough, ON, K9J 7B8, Canada. **Modeling DOC Fluxes and Runoff Changes in Pefferlaw River Watershed - A study of Climate Change Impact.**

The production and degradation of dissolved organic carbon (DOC) are important processes in the global carbon cycle. In many ecozones in Canada, DOC exceeds inorganic carbon species in lakes and rivers, and is the dominant carbon form transported downstream. It is also recognized that DOC degradation, either photochemically or microbially, is a significant source of carbon dioxide. The effects of climate and land use change on freshwater ecosystems can be manifested in a number of ways. One of these is through changes in the hydrologic cycle including runoff; which may alter DOC flux. However, not much is known about the combined effect of these factors on DOC fluxes in environment. We have used a hydrologic model (HBV) coupled with a process based biogeochemical model (INCA-C) to evaluate the effects of potential land use and climate change-induced runoff changes on the transport of DOC in the Pefferlaw River watershed, a major tributary of Lake Simcoe in the Great Lakes basin.

**Keywords:** Climate change, Dissolved organic matter, Lake Simcoe.

OPFER, S.E.¹, FARVER, J.R.², MINER, J.G.¹, and KRIEGER, K.A.³, ¹Bowling Green State University, Department of Biological Sciences, Bowling Green, OH; ²Bowling Green State University, Department of Geology, Bowling Green, OH; ³Heidelberg College, Department of Biology-Water Quality Lab, Tiffin, OH. **Sediment Heavy Metal and Burrowing Mayfly Distribution in Western Lake Erie.**

Before pollution abatement programs, heavy metals contaminated sediments in the western basin of Lake Erie mainly through the Detroit River, but also from lower discharge sources such as the Maumee and Ottawa rivers. Although measurable declines in sediment contamination have occurred, contaminant loading from these major discharges continues today. During the past two decades, burrowing *Hexagenia* mayflies have returned to the western basin of Lake Erie. Because of their importance as a prey resource for higher trophic levels and distribution in the sediment, mayfly nymphs may be a source of heavy metal transfer. To better understand the current distribution of both heavy metals in sediment and mayflies, we collected water, sediment, and nymphs from 24 locations across the western basin of Lake Erie in May 2007. Following EPA protocols, samples were analyzed for 16 elements using ICP-OES. Sediment heavy
metal distribution profiles indicate that highest concentration occurred in the middle of the western basin pointing to a Detroit River source. *Hexagenia* were distributed throughout the western basin, but were at highest density (1,350/m²) within the Detroit River plume. Thus, *Hexagenia* by consuming contaminated sediments in western Lake Erie can be a source of heavy metal uptake by fish. **Keywords:** Lake Erie, Environmental contaminants, Macroinvertebrates.

**OUELLETTE, J.C., DILLON, P.J., and AHERNE, J., Trent University, Peterborough, ON.** Spatial Landscape-scale Modeling of Dissolved Organic Carbon (DOC) Flux in the Lake Simcoe Watershed.

Dissolved Organic Carbon (DOC), a dynamic material able to be transported and transformed through numerous natural biogeochemical processes, fulfills many roles in maintaining freshwater ecosystem integrity. DOC is changing across the northern hemisphere; affecting factors such as climate and acidification. The Lake Simcoe watershed (LSW), a large (3,303 square kilometer) mixed-landcover catchment, consisting of more than 20 percent water by total area, is an ideal site to study DOC dynamics. A new steady-state empirical model, refined from one created for the Muskoka River watershed; a near pristine forested landscape, was derived for application within the mixed agricultural/urban/forested environments of the LSW. This new model was further calibrated and verified for several catchments and sampling stations, utilizing extracted spatial parameters acquired from manipulating and processing various Geographical Information System (GIS) layers. **Keywords:** GIS, Dissolved organic matter, Biogeochemistry.

**OZERSKY, T.¹, BARTON, D.R.¹, HECKY, R.E.², and GUILDFORD, S.J.², ¹University of Waterloo, 200 University Ave. W., Waterloo, ON, N2L3G1; ²University of Duluth, 1035 Kirby Dr., Duluth, MN, 55812.** Nutrient Flux through Invasive Mussels: Dreissenids as a Benthic-pelagic Nutrient Linkage.

Dreissenid mussels are one of the most important aquatic invaders in North America, having had large impacts on a wide array of ecological parameters in numerous lentic and lotic systems. The ability of dreissenids to exert strong effects on ecosystems is caused by their often enormous biomass, as well as by their role as a benthic-pelagic coupling mechanism, redirecting particulates from the water column to the benthos, while remineralizing a portion of the redirected material into a dissolved form. Results from previous laboratory experiments showed that dreissenid mussels could be a significant source of bioavailable dissolved nutrients, modifying the way nutrients are cycled and utilized in invaded systems. We present and discuss data from in situ microcosm experiments designed to assess the magnitude and direction of nutrient flux through undisturbed dreissenid populations in Lake Simcoe. Results indicate that dreissenid mussels are an important link in the nutrient cycle of invaded systems, removing particulate nutrients from the water column, and excreting significant amounts of bioavailable phosphorus and nitrogen. The ability of mussels to impact nutrient cycles should not be ignored in phosphorus budget estimates and management decisions. **Keywords:** Dreissena, Nutrients, Lake Simcoe.
OZERSKY, T.¹, MASON, K.⁴, SKINNER, A.J.², DEPEW, D.C.¹, EVANS, D.O.², BARTON, D.R.¹, GUILDFORD, S.J.³, and HECKY, R.E.³, ¹University of Waterloo, 200 University Ave. W., Waterloo, ON, N2L3G1; ²Ontario Ministry of Natural Resources, Trent University, 2140 East Bank Dr., Peterborough, ON, K9J 7B8; ³University of Minnesota, 1035 Kirby D, Duluth, MN, 55812; ⁴Golder Associates, 940-6th Ave. S.W., Calgary, AB, T2P 3T1. **Post-dreissenid Changes in Lake Simcoe’s Crayfish Community.**

Currently, invasive dreissenid mussels comprise a substantial part of Lake Simcoe’s macrobenthos, especially in the littoral zone of the lake. Dreissenids can have a number of effects on aquatic ecosystems, among them the shunting of carbon and nutrients from the pelagic to the benthic environment, and physical re-engineering of the benthic environment through deposition of shell and organic material. We hypothesize that both mechanisms could be important in explaining post-dreissenid changes to the crayfish community of Lake Simcoe, where crayfish are an abundant and important part of the benthos, acting as predators, grazers, decomposers, prey items, and ecosystem engineers. We present data showing significant increases in total abundance of all crayfish, as well as increases in the relative abundance of *O. virilis* at rocky sites and very localized high densities of the recently invading rusty crayfish. We also present an initial test of the benthic energy-shunt hypothesis based on stable isotope analysis of pre- and post-dreissenid samples of *O. propinquus*, a dominant species of crayfish in the lake.

**Keywords:** Lake Simcoe, Zebra mussels, Crayfish.

PAGANO, J.J., Department of Chemistry, State University of New York at Oswego, Oswego, NY, 13126. **Utilization of Salmonid Eggs as Bioindicators of Organohalogen Pollutants in Lake Ontario.***

Understanding the linkage between pollutant sources and monitoring the important endpoints (such as concentrations in salmonids and lake trout) is essential information for making management decisions within the Lakewide Management Plan (LaMP) process. Coho and Chinook eggs and muscle fillets were sampled at the Salmon River Fish Hatchery, Altmar, New York during the 2002-2006 spawning runs. Results from this study strongly suggest that salmon eggs perform as effective time-integrated biomarkers of critical and emerging contaminants found in the Lake Ontario ecosystem. Significant correlations were observed for polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs) between eggs and muscle tissue for Chinook and coho salmon. Results of salmon egg and muscle tissue regression analyses indicates a strong quantitative relationship for PCBs (r² = 0.96 and r² = 0.98) and PBDEs (r² = 0.95 and r² = 0.98) between eggs and maternal muscle tissue for both Chinook and coho salmon, respectively. The significance of the relationships observed indicate that yearly monitoring of salmonid eggs has the potential to provide a practical and inexpensive bioindicator of the overall health of the Lake Ontario ecosystem. **Keywords:** Bioindicators, PCBs, Lake Ontario.

PARKER, S.R., Parks Canada, Fathom Five National Marine Park, Tobermory, ON, N0H2R0. **A Legacy in a Sweetwater Sea: Experience from Canada’s First National Marine Conservation Area.**

Canada’s National Marine Conservation Area program was launched in 1987 with the establishment of Fathom Five National Marine Park at the tip of the Bruce Peninsula in Lake Huron. This
designation builds on a long history of protection in the Tobermory archipelago dating back to the naming of Flowerpot Island as part of Georgian Bay Islands National Park in 1930 and the establishment of Fathom Five Provincial Park in 1972. Management experience has matured in a variety of areas: a well established dive safety program and vessel-operating policy; shoreline development review process; and collaborative intergovernmental initiatives. Fathom Five has developed a national profile as a key area for Great Lakes research and condition monitoring. Opportunities for meaningful visitor experience and education outreach programs have successfully engaged people on marine issues. On-going challenges include finding greater relevance and representivity in the marine region, evaluating management effectiveness, and further engaging the growing population around the Great Lakes.

Keywords: Conservation, Protected areas, Management, Lake Huron.

PATERSON, G., 1, WHITTLE, D.M. 2, DROUILLARD, K.G. 3, and HAFFNER, G.D. 3, 1Worsfold Water Quality Centre, Trent University, 1600 West Bank Dr., Peterborough, ON, K9J 7B8; 2Department of Fisheries and Oceans, Great Lakes Laboratory for Fisheries and Aquatic Sciences, 867 Lakeshore Road, Burlington, ON, L7R 4A6; 3Great Lakes Institute for Environmental Research, University of Windsor, 401 Sunset Ave., Windsor, ON, N9B 3P4. Latitudinal and Temporal Declines in Great Lakes Lake Trout Energy Densities.

This study used surveillance data on lake trout (Salvelinus namaycush) collected from four Great Lakes during the period 1995 - 2004 to investigate latitudinal and temporal trends in biological characteristics of this top predator. Lake trout weight at age, average body mass, and energy densities had negative relationships with latitude. However, between the periods 1995 - 1999 and 2000 - 2004, body masses declined an average of 17% for fish collected from Lakes Erie, Ontario, and Superior, with only individuals collected from Lake Huron exhibiting increases in body mass during these periods. Additionally, energy densities declined consistently by 13% across these lakes from 1995 - 1999 to 2000 - 2004. Von Bertalanffy growth models describing the relationships between energy density and age demonstrated decreased growth of lake trout energy densities during 2000 - 2004 relative to 1995 - 1999. Asymptotic energy densities (Q∞) generated from the growth models also declined 3 - 13% among the lakes from 1995 - 2004. While the latitudinal trends in body mass and energy densities primarily reflected patterns in system productivities, the temporal declines in these characteristics are hypothesized to be due to changes occurring in Great Lakes pelagic forage fish populations. Keywords: Latitudinal, Temporal, Declines.

PAUL, J. and FREELAND, J.R., Department of Biology, Trent University, Peterborough, ON, K9J 7B8. Invasive Phragmites in the Great Lakes Region. II. Population Genetics of Invasive and Native Lineages, and the Role of Local Adaptation.

Invasive species have the potential to disrupt ecosystems and out-compete native species, and they collectively cost billions of dollars each year in prevention and control. Invasive species currently pose one of the biggest threats to the Great Lakes region, with one of the most problematic invaders being an invasive lineage of the common reed, Phragmites australis. This lineage apparently originated in Europe, where it exists in stable, non-invasive populations. It is unclear whether the rapidly increasing range of
Phragmites around the Great Lakes is attributable to a single, plastic genotype, or to multiple genotypes that are each adapted to different sets of environmental conditions. We are addressing this question with a combination of genotypic and environmental data from Phragmites populations in North America (including the Great Lakes region) and Europe. Our goal is to determine the role of adaptation in the movement of invasive Phragmites across the landscape. Keywords: Wetlands, Invasive species, Habitats.


Large cyanobacterial blooms reoccur in both Lakes Erie and Ontario. Regular monitoring of these potentially harmful blooms is important for implementing prompt water protection strategies. Such efforts necessitate a monitoring method that is reliable and easy to employ. A flow-through monitoring system composed of three commercial fluorometers (Turner Designs Algaewatch, Turner Designs Cyanowatch, and a Hydrolab) was installed on board the CCGS Limnos in the summer of 2007 to provide continuous real-time data on algal blooms throughout the two lakes. To standardize fluorescence measurements between cruises, fluorometers were calibrated pre-cruise using a standard Rhodamine WT solution. Calibration was monitored routinely en-route with the standard solution to ensure fluorescence data stability (i.e., check for instrument drift). The real-time fluorescence data were then compared to extracted chlorophyll and phycocyanin concentrations in order to map algal distribution. The effectiveness of fluorometer calibration and accuracy of resulting bloom mapping will be discussed. Keywords: Monitoring, Harmful algal blooms, GIS.

PAYTON, A.1, WATSON, S.B.2, ELSBURY, K.1, and KENDALL, C.3, 1Institute of Marine Sciences, University of California Santa Cruz, Santa Cruz, CA, 95064; 2Canada Centre for Inland Waters, Environment Canada, Burlington, ON, L7R 4A6; 3U.S. Geological Survey, 345 Middlefield Road, MS 434, Menlo Park, CA, 94025. Phosphate Sources and Cycling in Lake Erie an Isotope Signatures Approach.

Recently Lake Erie has shown increasing nutrient concentrations in inshore areas, while productivity may be dropping in deeper waters. It is believed that the lake is once again receiving substantial nutrient inputs (nitrogen and phosphorus) from both terrestrial (runoff, rivers, groundwater) and atmospheric (dry and wet deposition) sources. It has been suggested that water-source nutrient enrichment (from sewage, fertilizer, manure, and detergents) and atmospheric deposition are among the factors responsible for the observed recent shift in lake conditions. Efforts to identify and quantify the sources, fluxes, and fate of nutrients are extensive. However, these efforts are limited to stream water-quality monitoring and some atmospheric input estimations using water aerosol and rain collection. These data are coupled with modeling of input fluxes, deposition, utilization, and cycling of the nutrients to evaluate possible impacts to the ecosystem. We present preliminary data from novel isotope analyses of phosphate and nitrate in potential sources and within the lake in order to help us better identify and quantify the sources (point and non-point), constrain the P and N cycling dynamics within the lake, and
estimate the impact of nutrient loading on the lake ecosystem. **Keywords:** Stable isotopes, Lake Erie, Pollution sources.


Since 1976, the Canadian Wildlife Service has conducted surveys of all colonial waterbird colonies on the Great Lakes and connecting channels, at approximately 10 year intervals. In 2007, the first phase of the fourth “decadal” census was completed for the Detroit (DR) and Niagara (NR) rivers and Lake Erie (LE). Ground counts of all apparently occupied nests were conducted in May for herring (HERG) and ring-billed (RBGU) gulls and Caspian (CATE) and common (COTE) terns; Double-crested cormorants (DCCO), great blue herons (GBHE), great egrets (GREG) and black-crowned night-herons (BCNH) were censused in June. All eight species were present on LE (at 13 colonies); only HERGs, RBGUs and BCNHs nested on DR (at 5 colonies) and NR (at 12 colonies). Compared to the last census period (1997-2000), nesting pairs of DCCOs (12,186 nests, +63.9%), BCNHs (500 nests, +45.3%; first time nesting on DR) and GREGs (61 nests, +90.6%) increased in the region. CATEs (300 nests at one colony in LE) had not been recorded nesting on these water bodies during previous surveys. HERGs (2,541 nests, -20.1%), RBGUs (65,876 nests, -27%) and COTEs (14 nests, -97.4%) all exhibited a decline. **Keywords:** Avian ecology, Species composition, Cormorants.

**PENG, F.**, 1, **EFFLER, S.W.**, 1, **O’DONNELL, D.M.**, 1, and **LESHKEVICH, G.**, 2, 1Upstate Freshwater Inst., P.O. Box 506, Syracuse, NY, 13214; 2NOAA Great Lakes Environmental Research Laboratory, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105. **Individual Particle Analysis of Suspended Minerogenic Particles in Lake Erie: Implications to Water Clarity and Remote Sensing.**

Suspended inorganic, or minerogenic, particles from the western portion of Lake Erie, collected following a high wind event (September 2007), were characterized by an individual particle technique, scanning electron microscopy interfaced with automated X-ray microanalysis and image analysis (SAX). SAX provided characterizations of the elemental X-ray composition, number concentration, and particle size distribution. This information supported Mie theoretical calculations of the associated scattering \(b_m, \text{m}^{-1}\) and backscattering coefficients \(b_{bm}, \text{m}^{-1}\) and partitioning these two estimates into geochemical particle types to evaluate optical impacts and origins of the minerogenic particle population. Wide spatial differences in \(b_m\) and \(b_{bm}\) were observed, with clay minerals dominating at most sites. These spatial differences were the primary driver of the variations observed in several related bulk optical metrics, including turbidity, the beam attenuation coefficient, Secchi transparency depth, and particulate scattering and backscattering coefficients. **Keywords:** Individual particle analysis, Lake Erie, Remote sensing, Optical properticles, Turbidity, Suspended particles.
PENNUTO, C.M., KRAKOWIAK, P.J., and JANIK, C., Biology Dept. & Great Lakes Center, 1300 Elmwood Ave., Buffalo, NY, 14222. **Seasonal Abundance and Summer Energy Consumption by Round Gobies (Apollonia melanostoma) in Lake Erie Tributary Streams.**

Round gobies are well-established in all five of the Great Lakes, and in many tributary streams and rivers where they can have significant impacts on invertebrate communities and energy pathways. We assessed seasonal abundance of round gobies in two tributary streams while examining summer diet composition and energy consumption. Gobies began migrating into streams in April and exhibited a peak abundance in October, followed by a decline through January when no fish were found. Recruitment of YOY peaked in July, but new recruits were added at a low background rate into October. In summer, available invertebrate prey held significantly different energy contents with riffle beetles the most energetically profitable and molluscs (shell included) the least. Round gobies did not feed randomly on available invertebrates, showing a strong preference for Chironomidae even though these prey were nearly the least energetically profitable. Energy gained from amphipod consumption was nearly 30x greater than energy acquired from consumption of chironomids. In this study, an average round goby was estimated to consume ~1% of the invertebrate energy available per m² per day. These data suggest round goby migration into tributary streams during the open water season will have significant impacts on invertebrate communities and energy dynamics. **Keywords: Invasive species, Fish diets, Bioenergetics.**

PERDUE, J.¹ and FOX, M.G.², ¹Department of Biology, Trent University, Peterborough, ON, K9J 7B8; ²Environmental & Resource Studies Program and Department of Biology, Trent University, Peterborough, ON, K9J 7B8. **Age Determination in the Round Goby; Comparison of Scales and Otoliths.**

Round gobies captured from the Trent River, Ontario and kept in captivity from June to September 2006 were used to compare age estimates determined from scales with those determined from lapillus otoliths. Gobies were marked and held at ambient water temperatures, and individuals were divided into four groups (two controls and a high and low temperature treatment). The latter groups were subjected to three temperature treatments of three-day duration (28°C or 19°C) in order to determine whether high or low temperature change would induce the formation of false annuli on scales or otoliths. No false annuli developed on either the scales or the lapilli of any fish over the study period. While minor checks were visible on some specimens, they were not distinct or continuous enough to confuse age estimates. Scale and otolith age estimates agreed in 91.5% of cases, with an additional annulus evident on the otoliths in most cases where age estimates differed. Back-calculations of length at age suggest that the additional annulus that appeared on these lapilli is false. We conclude that age determination with scales is more accurate than with otoliths in the round goby. **Keywords: Round goby, Invasive species, Fish populations.**

PERKINS, M.G.¹, EFFLER, S.W.¹, STRAIT, C.M.¹, QUARING, G.F.¹, ZHANG, L.¹, and LESHKEVICH, G.², ¹Upstate Freshwater Institute, PO Box 506, Syracuse, NY, 13214; ²NOAA/Great Lakes Environmental Research Laboratory, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105. **Patterns of Light Absorption in the West Basin of Lake Erie.**
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; $a_{\text{CDOM}}$), phytoplankton ($a_{\text{phyto}}$), and non-algal particles (NAP; $a_{\text{NAP}}$) were determined for near-surface waters at 15 sites in Lake Erie (mostly within the west basin), for samples collected in September 2007 following a major wind event. Absorption spectra were obtained on filtrate (0.2 μm pore size) for CDOM, and filters for phytoplankton and NAP (before and after bleaching). Exponential decreases with increasing wavelength (400-700 nm range) for $a_{\text{CDOM}}$ and $a_{\text{NAP}}$, and bimodal patterns for $a_{\text{phyto}}$, are reported. Dependencies of $a_{\text{phyto}}$ and $a_{\text{NAP}}$ on the common water quality metrics of chlorophyll $a$ and suspended solids are evaluated. Wide spatial differences in the magnitudes of the three components and their relative contributions to overall $a$ are documented. Comparisons are made with recent observations for Lake Superior and Lake Ontario. Keywords: Lake Erie, Remote sensing, Underwater optics.

PERNANEN, S.K., Central Lake Ontario Conservation Authority, 100 Whiting Ave., Oshawa, ON, L1H 3T3. Using Regional Coastal Wetland Monitoring to Support Restoration and/or Adaptive Management at a Site Level.

Great Lakes coastal wetlands have decreased in size and/or quality during the recent past, but Durham Region still retains a number of examples. A variety of stakeholders have identified the need for conservation and monitoring of these important ecosystems and, in response, the Durham Region Coastal Wetland Monitoring Project (DRCWMP) was initiated by Environment Canada – Canadian Wildlife Service and the Central Lake Ontario Conservation Authority in conjunction with adjacent Conservation Authorities and other partners. The project, which began in 2002, was designed to implement a coordinated, multi-partnered approach to monitoring the biological and geophysical condition of 15 coastal wetlands along an 80-kilometer stretch of shoreline on Lake Ontario’s north shore. This talk will demonstrate how a regional monitoring plan can help to identify issues with specific biological communities at a site level, and to support existing management and restoration initiatives. Keywords: Coastal wetlands, Monitoring, Ecosystem health.

PETER, M.C.S., UGC Project on Husk Retting, Department of Zoology, University of Kerala, Kariavattom, Thiruvananthapuram, 695 581, India. Mechanism of Stress Tolerance in Fishes Living in Coconut Husk Retting Ground of Lake Paravur in South India.

Stress is a condition of threatened physiological homeostasis as result of exposure to stressors. Coconut husk retting, a common practice in the Lake Paravur in south India, is an essential step in the production of coir which releases toxic effluents including ammonium and nitrates. Teleosts have evolved strategies to maintain metabolic and osmotic regulation with the help of endocrines including interrenal and thyroid. We studied the indices of these vital processes and quantified the hormones of these endocrines in climbing perch and in tilapia after exposing them to coconut husk retting effluents. Our data point that these fish tolerate the CHRE-induced metabolic and osmotic disturbances with support of
Physiological Response of Air-breathing Perch (Anabas testudineus Bloch) to Coconut Husk Retting Effluent from Lake Paravur of Southern India.

To understand the physiological mechanism of stress tolerance in fish living in coconut husk retting grounds, we examined the metabolic pattern and thyroidal activities in the air-breathing perch, Anabas testudineus after exposing them to the effluent of coconut husk retting (CHRE). Triiodothyronine (T3) and thyroxine (T4), the primary hormones of thyroid, were measured in the plasma of these fish together with the indices of metabolic regulation. Five days of CHRE exposure decreased the plasma T4 without affecting the plasma T3. The concentration of plasma glucose, triglycerides, and urea were significantly increased in the CHRE-exposed fish. Significant reduction in the concentration of liver total protein, RNA, and DNA occurred in the CHRE-treated fish. CHRE treatment while increasing the alanine aminotransferase and alkaline phosphatase activities, decreased the aspartate aminotransferase in the liver. Besides identifying plasma glucose as the reliable biomarker of CHRE-induced stress, our results suggest that these fish reallocate their energy resources during stress where thyroid gland has a major role to play. (Funded by University Grants Commission, New Delhi MRP F-30-205/2004/SR)

Sustainable Development and Restoration Opportunities at AOC Sites.

Begin with the end in mind. Integrating remediation and pollution control efforts with waterfront use and development, ecosystem restoration, and habitat creation efforts can result in breakthrough opportunities to accomplish sustainable restoration of contaminated water ways. Typically, the restoration of degraded aquatic systems follows a sequential path of isolated actions from source control to remediation to ecosystem restoration and property development. Each of these stages has focused objectives that are limited to meeting only the goals of that particular stage. Each of the alternatives in these stages are conceived and compared with one another using criteria that are typically important only to meeting the immediate objectives. With this potentially myopic approach, there are likely opportunities that are missed to creatively restore elements of the system or create new sustainable elements as a part of the remedial action. Missed too are synergies that at worst could save costs and at best could help “sell” and potentially help fund the project and make an otherwise impossible project possible. Examples of the application of this concept will be presented for several sites, including the Don River watershed in Toronto. Keywords: Remediation, Restoration, AOCs.
PILEGGI, V.\(^1\), ROSENTHAL, H.\(^2\), and SCHROEDER, J.\(^1\), \(^1\)MOE, Standards Development Branch, 40 St. Clair Ave. West, 7th Fl, Toronto, ON, M4V 1M2, Canada; \(^2\)MOE, Land and Water Policy Branch, 135 St. Clair Ave. West, 6th Fl, Toronto, ON, M4V 1P5, Canada. **A Survey of Ontario Sewage Treatment Plant Discharges and Landfill Leachates in the Great Lakes Basin.**

From 2004-2005, the Ministry of the Environment surveyed selected STPs and landfill sites. The objectives were to: characterize the influent, effluent, and sludge over four seasons; compare results to the ministry’s previous survey in 1987; compare discharges of plants receiving leachate to those not receiving leachate; and identify substances in the effluents that warrant assessment for risks to human or environmental health. All STPs efficiently reduced the concentrations of conventional parameters (CBOD\(_5\), COD, TSS, TP, and TAN) consistent with the level of treatment provided. Reduction of non-conventional substances in the effluent was generally compound specific and not treatment dependant. Partitioning to sludge appeared to be an important process for many contaminants. Compared to the 1987 survey, loadings of Hg and Ni were reduced but Sr and Al were increased. Municipal landfill leachates were found to contain a large number of the same complex chemicals found in typical STP influents but generally at higher concentrations. However leachate did not significantly influence the effluent or sludge concentrations except for Mg and Sr in the effluent and Sr in the sludge. Based on a screening-level comparison to ecological and human benchmarks, 13 compounds were flagged as warranting further investigation. **Keywords:** Environmental contaminants, Comparison studies, Great Lakes basin.

POOS, M.S.\(^1\), TU, C.\(^2\), and JACKSON, D.A.\(^1\), \(^1\)Department of Ecology and Evolutionary Biology, University of Toronto, 25 Harbord St., Toronto, ON, M5S3G5; \(^2\)Toronto Region Conservation Authority, Ecology Division, 5 Shoreham Road, Downsview, ON, M3N 1S4. **Using Meta-population Viability Analysis to Quantify Risks of Urbanization on Two Populations of Redside Dace (Clinostomus elongatus).**

The ability to improve recovery strategies through an integration of both a metapopulation (patch size, connectivity) and a habitat (e.g., water quality, stream form) paradigm can provide critical insights into aquatic species recovery; especially since aquatic systems are thought to have considerably higher rates of species imperilment than their terrestrial counterparts (Ricciardi and Rasmussen 1999). We are using the redside dace as a model organism for improving management objectives by considering an integrative meta-population-habitat approach. The redside dace is a model organism because it has a largely fragmented distribution in the tributaries of the Great Lakes (McKee and Parker 1982; Andersen 2002; Holm 2003) and declines in redside dace have been attributed to changes in land-use (e.g., urban) and habitat quality (e.g., stream form). We use visual implant elastomer tags (VIE) to quantify population dynamics in two redside dace populations in an urban system; one undergoing high urbanization, the other not. Using meta-population viability analysis, we demonstrate that population parameters such as patch occupancy and population persistence are greatly reduced in the highly urbanized setting. We examine relationships of population decline using habitat parameters and draw conclusions to improve recovery. **Keywords:** Fish tagging, Fish populations, Urban watersheds.
POSTE, A.E.1, HECKY, R.E.2, YAKOBOWSKI, S.1, DYBLE, J.3, and GUILDFORD, S.J.2, 1University of Waterloo, 200 University Ave. W., Waterloo, ON, N2L 3G1; 2University of Minnesota–Duluth, University of Minnesota, Duluth, MN, 55812; 3NOAA, Great Lakes Environmental Research Laboratory, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105. **Microcystin in Water and Fish from East African Lakes.**

Despite evidence of shifts toward cyanobacterial dominance and increased frequency of cyanobacterial blooms in African lakes, few studies have quantified cyanotoxins in these lakes. Epilimnetic water and fish were collected in May 2007 from Lake Albert and Lake Saka. Microcystin in whole water was measured using a Protein Phosphatase Inhibition Assay, and fish muscle tissue was analyzed for microcystin using methanol extraction and ELISA. In Lake Albert, the mean whole water microcystin concentration was 0.06 μg/L, far below the WHO drinking water guideline of 1.0 μg/L. However, microcystin in Lake Albert fish was still detectable and ranged from 0.47 to 5.66 ng/g. The highest concentration seen approached the WHO guideline for microcystin in fish (TDI of 40 ng/g consumer, for a 50 kg individual consuming a daily fish meal of 300 g) and was observed in the smallest individual of *Lates niloticus* (Nile perch). In Lake Saka, where microcystin in water persistently exceeds 3 μg/L, the *Oreochromis niloticus* (Nile tilapia) collected all exceeded the recommended TDI for microcystin in fish, with concentrations ranging from 6.95–30.41 ng/g, indicating that microcystin concentrations in these fish may be detrimental to the health of consumers. **Keywords: Africa, Microcystin, Fish.**

POTHOVEN, S.A.1 and NALEPA, T.F.2, 1National Oceanic and Atmospheric Administration, Great Lakes Environmental Research Laboratory, Muskegon, MI, 49441; 2National Oceanic and Atmospheric Administration, Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 48105. **Fish Diets and Condition in Lake Huron.**

We collected seasonal data on planktivorous fish condition, diets, and available prey (zooplankton, *Mysis*, benthos) from a site in southern Lake Huron in 2007. Diets and condition were compared to earlier data collected from Lake Michigan. The two most abundant pelagic planktivores in Lake Huron were rainbow smelt and bloater. Both rainbow smelt and bloater diets (by number) were mainly copepods (70% and 90% respectively), with smaller contributions from cladocerans (23 and 9% respectively) and *Mysis* (5 and 1% respectively). Diet composition in Lake Huron in 2007 differed from that for fish from Lake Michigan (2000-2001), where smelt mainly ate cladocerans (56%), copepods (20%), and *Mysis* (12%) and bloater ate cladocerans (62%), *Mysis* (16%), *Diporeia* (8%), and copepods (3%). Diets will be further analyzed with respect season and to available prey resources for both lakes. Energy density in the spring for rainbow smelt was apparently lower in Lake Huron in 2007 (4,295 J/g) than in Lake Michigan (1998-1999) (5,894-6,528 J/g). On the other hand, energy density of bloater in the spring was similar between Lake Huron (6,690 J/g) and Michigan (5,829-7,002 J/g). **Keywords: Fish diets, Lake Huron, Fish.**

POULOPOULOS, J. and CAMPBELL, L.M., Department of Biology and School of Environmental Studies, Queen's University, Kingston, ON. **Analysis of Archived Fish from Lakes Nipigon, Simcoe, and Champlain to Assess Impacts of Exotic Fish Species on Food Webs and Hg Biomagnification.**
Exotic species have altered food webs and exposure of native species to the biomagnifying chemical mercury (Hg) in many aquatic ecosystems. In particular, Lakes Nipigon, Simcoe, and Champlain represent a gradient of impacts from relatively pristine northwestern Ontario, toward the more impacted southern Ontario and Vermont. We are performing stable isotope analyses on archived fish collected in the 1920s – before the arrival of most exotic species to our study lakes – and on more recently-captured fish, to determine how exotics have changed food web structures over the last 80 years. Results to date indicate a well-conserved stable isotope composition among lower trophic levels through time, but changes at higher levels that may be due to the energetic pressures of exotic species. As part of this project, we are assessing Hg biomagnification in modern food webs by measuring fish Hg concentrations at different trophic levels. Through analysis of archived fish, it may be possible to evaluate historical Hg concentrations as well, assuming they have not been altered by chemical preservation. We are investigating this possibility and expect to be able to compare Hg biomagnification in historical and contemporary fish, and gauge whether, by altering trophic structures, exotic species have changed patterns of Hg contamination. Keywords: Isotope studies, Mercury, Invasive species.


Echo sounders, sidescans, and multibeam sonar provide complimentary acoustic information about lake, river, and seabed sediments. Echoes and sonar images can be processed to produce habitat maps; in as much as bottom type contributes to habitat. Quester Tangent (QTC) is a world leader in hardware and software for acoustic remote sensing and classification. QTC hardware acquires high-fidelity digital versions of sounder echoes. QTC software suites classify either echoes or images by generating features that capture characteristics such as echo duration and image texture. Variance in a set of features is concentrated with Principal Components Analysis and acoustic classes determined by automated objective clustering. Quality control is important, and many tools for this are included. Classification results can be brought into any GIS. Data can be exported at several stages in the classification process, should alternative statistical methods be preferred. Examples of shallow-water surveys and the resulting class maps will be presented. Keywords: Acoustics, Seabed classification, Sediments, Remote sensing.


_Hemimysis anomala_ (Crustacea: Mysidacea) is a newly invasive species to the Great Lakes. Sampling was conducted near Oswego, New York in Sunset Bay during the summer of 2007 using horizontal night trawls. The mitochondrial cytochrome oxidase I (COI) subunit gene was sequenced from sixteen specimens. Results were compared to a published study on haplotypes diversity in _H. anomala_ from its native range in the Ponto-Caspian and a nonnative population in Lake Michigan (Audzijonyte _et al._ 2007). Those results identified a single haplotype in the introduced Lake Michigan population, indicating they invaded from the Danube. However, we identified several haplotypes in the Lake Ontario population that were not present in the Danube lineage, indicating that the Lake Ontario population may
have resulted from an invasion from the Dnieper region of the Black Sea instead. The possible occurrence of multiple introductions in the Great Lakes may contribute to the future long-term success of *H. anomala* in the region. **Keywords:** Crustaceans, Biological invasions, Genetics.

RAMKELLAWAN, J.¹, GHARABAGHI, B.¹, and WINTER, J.G.², ¹School of Engineering, University of Guelph, Guelph, ON, N1G 2W1; ²125 Resources Road, Ontario Ministry of the Environment, Toronto, ON, M9P 3V6. **Atmospheric Sources of Phosphorus to Lake Simcoe.**

High levels of phosphorus in Lake Simcoe have been attributed to the decline in lake water quality since 1970. Out of the estimated 53 to 67 t/yr of phosphorus entering the lake, atmospheric deposition is believed to be responsible for 16 to 38 t/yr. Historical estimates for atmospheric deposition involved averaging rain gauge and rain quality station data. Thus, through use of this procedure, any spatial variability in the data is lost as each gauge is given an equal weighting. This study investigates the use of Next Generation Radar (NEXRAD) to spatially represent rainfall data, as well as a method to correct radar-rainfall estimates to rainfall recorded by local rain gauges. It was found that the radar generally represented localized rainfall well, with the majority of correlation coefficients (R²) being over 0.90. For large bulk TP deposition events the dominant parameter in calculating TP loads is rainfall depth and the revised method provides a significant improvement in rainfall depth calculation. Results from this analysis demonstrated a large difference between historical and revised estimates of bulk atmospheric deposition of phosphorus over Lake Simcoe. **Keywords:** Lake Simcoe, Phosphorus, Atmosphere-lake interaction.

RAZAVI, R.¹, CAMPBELL, L.M.¹, HODSON, P.V.¹, and RIDAL, J.J.², ¹Queen's University, Department of Biology, BioSciences Building, Kingston, ON, K7L 3N6; ²St. Lawrence River Institute of Environmental Sciences, 2 Belmont St., Cornwall, ON, K6H 4Z1. **Does Gas Bubbling from Sediments Increase the Transfer of Mercury to Aquatic Food Webs?**

The St. Lawrence River near Cornwall, ON, is designated as an Area of Concern (AOC) due to the legacy of industrial mercury (Hg) inputs for over a century. Understanding Hg bioavailability is complicated by a paradox between patterns of contamination in yellow perch (*Perca flavescens*) and their prey items and contamination in sediments. Specifically, one zone exhibits higher than expected Hg uptake by biota. Methane gas produced as a result of decomposing fiber deposits are suspected of disturbing the natural burial processes which would reduce exposure of biota to old Hg deposits. Artificial substrates were used *in situ* to collect amphipods (*Gammaridae*) and gas measurements were taken over the deployment period. Corresponding sediment and porewater samples were preserved to assess uptake routes. Preliminary results from June and August 2007 indicate possible site avoidance by amphipods at high bubbling locations, and do not point to a relationship between bubbling rate and total Hg (THg) concentrations in amphipods. Increasing porewater THg concentrations correspond to high bubbling sites but still do not explain amphipod contamination. While bubbling may not affect mercury concentrations in amphipods directly, it is possible that bubbling forces amphipods into areas where they accumulate more Hg. **Keywords:** Sediment resuspension, Amphipods, Mercury.

An integrated assessment of nutrient loading was conducted in the Bear Lake watershed. Bear Lake is a 1.66 km² eutrophic drowned river mouth system that is included in the Muskegon Lake Area of Concern. The lake is scheduled for a Total Daily Maximum Load (TMDL) due to excessive nutrients and nuisance algal blooms. A ten fold increase in the loading of suspended sediment and phosphorus was noted from base flow to storm event conditions. Loadings from the tributaries were enhanced by a channelized stream and highly modified wetlands near the inlet to Bear Lake. While storm events accelerated phosphorus loading to Bear Lake, the presence of heavy cyanobacteria blooms, elevated chlorophyll-α concentrations, and low Secchi disk depth readings throughout the summer were indicative of an internal sediment loading source. An analysis sediment and water quality, bathymetry, and thermal profiles determined that sediment resuspension also was a significant source of nutrient loading. In addition, the Long-Term Hydrologic Impact Assessment Model was employed to estimate NPS loading from lake front property. Keywords: Watersheds, Water quality, Monitoring.

REDISKE, R.R.¹, HAGAR, J.¹, O’KEEFE, J.P.¹, HONG, Y.E.¹, and DYBLE, J.², ¹Annis Water Resources Institute, Grand Valley State University, Muskegon, MI, 49441; ²Great Lakes Environmental Research Laboratory, National Oceanic and Atmospheric Administration, Ann Arbor, MI, 48105. Cylindrospermopsis raciborskii in West Michigan Drowned River Mouth Lakes.

Cylindrospermopsis raciborskii is a tropical toxic-bloom-forming cyanobacterium that recently has been reported in the Lake Michigan basin. C. raciborskii populations were studied in 5 drowned river mouth lakes in west Michigan during 2006 (n=48). Maximum densities were 10 Tc/mL in Muskegon Lake, to 3,500 Tc/mL in Spring Lake. Beach samples had significantly higher populations than open water stations (p=0.02) in Spring Lake. No significant difference was observed between beach and open water samples in the other lakes. Cylindrospermopin was not detected in any of the water samples using HPLC/MS (LOD=0.01 μg/L). The presence of the putative genes for cylindrospermopin production was assessed using a set of PCR primers specific to a polyketide synthetase (PKS) gene in 6 samples containing the highest levels of the cyanobacterium. The Cylindrospermopsis-specific nifH primers amplified a PCR product from all 6 samples, indicating both that the DNA was intact and that C. raciborskii was present in the samples. Neither the more general cyanobacterial PKS or the Cylindrospermopsis-specific PKS primer sets successfully amplified a PCR product from the samples, despite strong amplification of the positive control. These data suggest that toxin producing strains were not present. Keywords: Cyanophyta, Harmful algal blooms, Invasive species.

Water availability is determined by the volume of water in storage, by the flow of water through the environment, and by the interaction of these with constraints. Constraints include existing water use, water quality, and ecological or other in-stream requirements. Each of these constraints depends upon societal decisions. The U.S. Geological Survey (USGS) is conducting a pilot study in the Great Lakes basin for a national initiative on water availability and use assessment. Goals of the pilot study include establishing a scientific framework for water availability quantification for the basin, developing methods to quantify indicators used to express water availability, and demonstrating application of potential techniques and methods to assess water availability. Constraints are important for the final determination of water availability for the region, but these constraints may vary between jurisdictions and depend on local conditions. The focus of the project, therefore, is on three main components: surface-water flows and storage, ground-water flows and storage, and water-use assessment. Keywords: Great Lakes basin, Regional analysis, Assessments.

REICHERT, J.M.¹, FRYER, B.J.¹, LUDSIN, S.A.², JOHNSON, T.B.³, TYSON, J.T.⁴, JOHENGEN, T.H.⁵, and HAWLEY, N.⁶, ¹Great Lakes Institute for Environmental Research-University of Windsor, 401 Sunset Ave., Windsor, ON, N9B 3P4; ²The Ohio State University, 1314 Kinnear Rd., 232 Research Center, Columbus, OH, 43212; ³Ontario Ministry of Natural Resources, R.R. #4, 41 Hatchery Lane, Picton, ON, K0K 2T0; ⁴Ohio Department of Natural Resources- Division of Wildlife, 305 E. Shoreline Dr., Sandusky, OH, 44870; ⁵CILER-University of Michigan, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105; ⁶NOAA-Great Lakes Environmental Research Laboratory, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105. River Plume Effects on Yellow Perch Growth, Survival, and Recruitment in Lake Erie.

Several tributaries drain into western L. Erie that differ in their physical (e.g., temperature, sediment inputs) and chemical (e.g., phosphorus inputs) properties. In turn, these river inflows lead to the formation of water masses (river plumes) that have distinct habitat characteristics, which could differentially influence the growth and survival of fish. Specifically, one might expect that nutrient-rich river plumes with higher temperatures (e.g., Maumee River plume) to promote faster larval fish growth, thus leading to increased survival and recruitment success, compared to river plumes without such attributes (e.g., Detroit River plume). To test this hypothesis, we are using otoliths from yellow perch larvae and juveniles collected during 2006 and 2007 to 1) compare daily growth rates between the Maumee and Detroit River plumes (n=25 larvae/date/plume/year), and 2) develop plume-specific micro-elemental signatures (n=50 larvae/plume/year) to reconstruct past larval habitat use of age-0 juvenile yellow perch from August (n=100 fish/year), which is when recruitment is set for this species in L. Erie. Herein, we present our research findings and discuss their implications for understanding how river plumes can influence recruitment variation of yellow perch, which is of recreational and commercial importance in L. Erie. Keywords: Chemical analysis, Otolith, Tributaries, Fish growth, Recruitment, Icthyoplankton.

REID, D.F.¹ and WILKINSON, D.², ¹National Oceanic and Atmospheric Administration-NCRAIS, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105-2945; ²National Oceanic and Atmospheric Administration-
The earliest and most extensive legislation on invasive species in the U.S. was for protection of crops and livestock. On the aquatic side, Federal policy until the late 20th Century was rare and primarily reactive, treating each introduced species as a separate problem. The discovery of the zebra mussel in 1988 catalyzed multiple laws and policy changes at many levels of government across the U.S. and Canada, recognizing aquatic invasive species as a national problem. In the U.S. the centerpiece has been the Nonindigenous Aquatic Nuisance Species Prevention and Control Act (NANPCA), originally passed in 1990. It included mandates on prevention (ballast water), and requirements aimed at zebra mussel control, as well as other actions, such as system surveys and establishment of the Aquatic Nuisance Species Task Force to encourage a coordinated Federal approach. It led to establishment of regional panels, and to EO 13112, which resulted in the first comprehensive national plan for managing invasive species issues within the United States. In Canada, the issue was recognized in the Canadian Biodiversity Strategy (1995), which led to the 2001 Canadian Action Plan to Address the Threat of Aquatic Invasive Species, resulting in recent changes in Canadian ballast water law and the establishment of an extensive scientific program. Keywords: Zebra mussels, Policy making, Environmental policy.


In January 2007, quagga mussels were discovered in Lake Mead, Nevada/Arizona, marking the first documented establishment of dreissenids west of the 100th meridian. Oregon Public Broadcasting is preparing an hour-long documentary on invasive species in Oregon. A short segment from that documentary will be played that focuses on the Lake Mead invasion and the fear, already being realized, that the mussels will spread throughout the western states. This video serves as a brief introduction to the next presentation, by Drs. A.N. Cohen and R.A. Moll, about the spread of dreissenids west of the 100th meridian and the local/regional response. Keywords: Invasive species, Zebra mussels, Distribution patterns.

REID, S.M.1, JONES, N.E.2, and YUNKER, G.B.2, 1Watershed Science Centre, Trent University, Peterborough, ON, K9J 7B8; 2Ontario Ministry of Natural Resources, Aquatic Research and Development Section, Peterborough, ON, K9J 7B8. Evaluation of Single-pass Electrofishing and Rapid Habitat Assessment for Monitoring a Species-at-risk Stream Fish, Redside Dace (Clinostomus elongatus).

To date, monitoring of the status of the provincially threatened redside dace in Ontario has been ad hoc or incidental to other sampling programs. We evaluated the efficacy of single-pass backpack electrofishing without block nets to detect redside dace, provide an index of abundance, and characterize size-class distributions. We also examined whether a rapid stream habitat assessment method was suitable for monitoring habitat condition at capture sites. Based on 40 sites across 7 Lake Ontario tributaries, catch data and length frequency distributions from single-pass sampling were compared to those from multiple-
pass depletion sampling. Single-pass electrofishing captured 47% of estimated redside dace abundance and 34% of biomass. Abundance and biomass data from the single-pass method were positively correlated (abundance $r^2 = 0.83$; biomass $r^2 = 0.52$) with estimates from the multiple-pass depletion method. Single-pass and multiple-pass length frequency distributions were not significantly different. The habitat assessment method failed to detect expected habitat differences between sites that contained redside dace and those that did not. Habitat monitoring could be improved by including more detailed measurements of fine sediment, pool depth, and riparian vegetation. **Keywords:** Habitats, Fish management, Monitoring.

RICCIARDI, A., Redpath Museum, McGill University, Montreal, QC, H3A 2K6. **Ecological Distinctiveness as a Driver of Exotic Species Impacts: Bivalves as a Case Study.**

While most aquatic invasions have no obvious impact, some cause substantial ecological disruptions. The ability to distinguish invaders likely to have a major impact from those having only minor effects is essential for prioritizing management efforts. Unfortunately, there exist few predictable patterns of impact for invasions, reflecting their context-dependent nature. A promising approach toward identifying predictable patterns is to test hypotheses that incorporate characteristics of both the invader and the invaded system. Using data from studies of dreissenid mussels and other introduced bivalves, I explored the hypothesis that an invader’s impact is determined by the invaded system’s evolutionary experience with similar species. The rationale for this hypothesis is that unique invaders are less likely to encounter enemies that can control their abundance (and, thus, limit their impact), and are more likely to encounter naïve competitors, predators and prey that are poorly-adapted to them. The hypothesis is supported by meta-analyses showing that introduced bivalves that add a novel ecological function to a system are more likely to disrupt the system. Furthermore, the taxonomic relationship of the invader to resident species appears to be a useful proxy variable for ecological distinctiveness. **Keywords:** Dreissena, Ecological impacts, Prediction.

RICHARDS, R.P., BAKER, D.B., and KRAMER, J.W., National Center for Water Quality Research, Heidelberg College, Tiffin, OH, 44883. **Record-setting Phosphorus Loads from Agricultural Watersheds in Ohio.**

Annual loads of total phosphorus and dissolved reactive phosphorus for the Sandusky and Maumee Rivers in Water Year 2007 were the highest observed in more than 30 years of monitoring these rivers. This is true in spite of downward trends in sediment and particulate phosphorus concentrations: sediment loads for 2007 were above average but not record-setting. The major reason for these extreme loads is the weather. 2007 had above-average but not record-setting rainfall (44.8”, 129% of the average since 1900), and a warm fall and winter supported tillage and fertilization, activities that are postponed until spring in colder years. During this time, which is often dry, there were frequent rains, which eroded bare soils and leached nutrients from crop stubble and applied fertilizer and manure. Rainfall for October through January was 173% of the average for this period. Exceedence analysis suggests that phosphorus loads this large should occur only about once per 100 years. This year indicates the extent to which the weather can dominate non-point source nutrient loading from agricultural watersheds, and illustrates the
challenge of developing models of to predict ecosystem responses to highly variable watershed inputs. 

*Keywords: Phosphorus, Pollution load, Tributaries.*

RIDAL, J.J. and HICKEY, M.B.C., St. Lawrence River Institute, 2 Belmont St., Cornwall, ON, K6H 4Z1. 

**The Role of NGOs in the RAP Process: The Evolution of the St. Lawrence River Institute of Environmental Sciences in the St. Lawrence River (Cornwall) RAP.**

The St. Lawrence River (Cornwall) RAP was initiated in 1986, encompassing an 80 km stretch of the river from Cornwall, Ontario to the Quebec border. Industrial, municipal and agricultural activities contributed to several impairments including restrictions on fish and wildlife consumption, loss of fish and wildlife habitat, eutrophication and beach closures. Early in the planning process, a lack of information on these issues within the context of a complex large river environment was identified. Strong local involvement led to the creation in the early 1990s of the St. Lawrence River Institute of Environmental Sciences (River Institute) as a NGO research and education institute. Since that time the River Institute has played a significant role in RAP implementation through research and outreach activities. The River Institute has been particularly successful in forging innovative partnerships with local municipalities, industry and universities to support research into key knowledge gaps. The River Institute’s diverse outreach and environmental education programs disseminate RAP information to the public. Central to its contribution has been an emphasis on building organizational capacity, particularly in establishing complementary funding sources that provide a measure of independence from government funding cycles. *Keywords: Public participation, Remediation, St. Lawrence River.*

RILEY, S.C.¹, MUNKITTRICK, K.R.², EVANS, A.N.⁴, KRUEGER, C.C.³, and DETTMERS, J.M.³, 
¹U.S.G.S. Great Lakes Science Center, 1452 Green Road, Ann Arbor, MI, 48105; ²Canadian Rivers Institute, University of New Brunswick, Saint John, NB, E2L 4L5; ³Great Lakes Fishery Commission, 2100 Commonwealth Blvd., Suite 100, Ann Arbor, MI, 48105; ⁴Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR, 97331. 

**Fish Health and Ecosystem Dysfunction in the Great Lakes.**

Disease may be an important variable affecting wild fish population dynamics in the Great Lakes; however, a lack of information on the ecology of fish disease currently precludes the prediction of risks to fish populations. We propose a conceptual framework for conducting ecologically-oriented fish health research that addresses the inter-relationships among fish health, fish populations, and ecosystem dysfunction in the Great Lakes. The conceptual framework describes potential ways in which disease processes may relate to ecosystem function, and suggests that functional ecosystems are more likely to be resilient with respect to disease events than dysfunctional ecosystems. We suggest that ecosystem- or population-level research on the ecology of fish disease is necessary to understand the relationships between ecosystem function and fish health, and to improve prediction of population-level effects of diseases on wild fish populations in the Great Lakes. These concepts are embodied in a research theme promoted within the Great Lakes Fishery Commission’s research program, which is designed to encourage ecologically-oriented research on fish disease in the Great Lakes. *Keywords: Fish diseases, Ecosystem health, Populations.*
RILEY, S.C. and ROSEMAN, E.F., U.S.G.S. Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105. **Deepwater Demersal Fish Community Collapse in Lake Huron: Implications for Monitoring of Great Lakes Fish Communities.**

Long-term fish community surveys were carried out by the U.S.G.S in the Michigan waters of Lake Huron using bottom trawls from 1976-2006. Trends in abundance indices for common species in trawl catches were estimated for two periods: early (1976-1991) and late (1994-2006). The round goby was the only species with a positive trend in abundance since 1994, and johnny darter and spottail shiner showed no significant trends; all other species significantly decreased in abundance during this period. Percentage decreases in abundance indices between 1994 - 2006 ranged from 66.4 to 99.9 percent, with seven species having decreased in abundance by greater than 90%, and the mean biomass of all common species in 2006 was less than five percent of that observed in the mid-1990s. Our observations suggest that the deepwater demersal fish community may be undergoing collapse. Trawl-based indices of fish abundance in Lake Huron are, however, subject to bias due to catchability, which may be affected by the presence of dreissenid mussels. We suggest that the use of multiple gears be considered for future fish community monitoring in the Great Lakes. **Keywords: Fish populations, Monitoring, Lake Huron.**

ROBERTS, J.J.¹, HÖÖK, T.O.¹, LUDSIN, S.A.², POTHOVEN, S.A.³, and VANDERPLOEG, H.A.³, ¹Cooperative Institute for Limnology and Ecosystems Research-University of Michigan SNRE, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105; ²Aquatic Ecology Lab-Ohio State University, 1314 Kinnear Rd., 232 Research Center, Columbus, OH, 43212; ³Great Lakes Environmental Research Laboratory, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105. **Bioenergetics Model to Explore the Effects of Hypoxia on Yellow Perch Habitat Quality in Lake Erie’s Central Basin.**

Seasonal hypolimnetic hypoxia recurs annually in the central basin of Lake Erie. While the ecological consequences of hypoxia on the food web of Lake Erie’s central basin are largely unknown, hypolimnetic hypoxia likely negatively affects habitat quality of yellow perch (*Perca flavescens*), a primarily demersal species of both economic and ecological importance. We are using a three-dimensional spatially-explicit bioenergetics modeling framework to synthesize field and laboratory data collected during 2005-2007 to test this hypothesis. Temperature, dissolved oxygen, and prey abundance (zooplankton and benthic macroinvertebrates) data collected as part of the 2005 IFYLE program were interpolated to generate 3-D estimates of biotic and abiotic environmental conditions. These estimates were then used as input to apply a 3-D yellow perch bioenergetics growth potential model, which incorporates laboratory results relating yellow perch consumption and growth to temperature, oxygen concentration, and prey availability. Preliminary results suggest that during a year of severe hypoxia, yellow perch habitat quality is deleteriously affected in the preponderance of hypolimnetic cells within Lake Erie’s central basin. Ultimately, we discuss the implications of these results for management of Lake Erie yellow perch. **Keywords: Fish, Bioenergetics, Lake Erie.**
An Overview of the 2007 Pilot Sanitary Surveys.

The U.S. EPA supports a long-term beach closure and advisory survey of beaches on the Laurentian Great Lakes. Waters used for recreational activities involving body contact should be substantially free from pathogens, including bacteria, parasites, and viruses, that may harm human health. Nine Pilot Sanitary Surveys ($525,000) were funded in 2007 to implement the use of the Sanitary Survey Pilot tool at sixty beaches in six of the Great Lake States and the Province of Ontario. During a generally dry summer in the Great Lakes basin, types of beach contamination sources are identified and potential sources of contamination were studied that did not contribute to beach bacterial contamination. Grantee’s proposed remediation measures for managing their beaches will be discussed. Remediation plan cost estimates and expectations for improvements in beach usage will be presented. Forecast models types used for predicting *E. coli* posting and expected improvement in beach management from the use of models will be discussed. Grantee's suggestions for improvement and recommendations for use of the beach sanitary survey tool will be presented. *Keywords: Great Lakes basin, Indicators, Planning.*

A Paleolimnological Reconstruction of Historical Lake Simcoe Cold-water Fish Habitat.

Since the start of European settlement (circa. 1800) in the watershed, phosphorus loading to Lake Simcoe has increased 3-fold. Concurrently, Lake Simcoe populations of lake trout (*Salvelinus namaycush*) and lake whitefish (*Coregonus clupeaformis*) have declined. This decline is due to poor population recruitment, attributed to eutrophication, causing a reduction in volume-weighted hypolimnetic oxygen (VWHO). Recent abatement efforts have succeeded in decreasing P inputs, and VWHO levels have recovered to a target value of 5 mg/L. However, cold-water fish populations continue to experience recruitment failure. A VWHO target of 7 mg/L may better reflect the oxygen optima of cold-water fish juveniles. This work aims to reconstruct historic VWHO values to determine how the cold-water fish habitat of Lake Simcoe has fluctuated since the onset of European settlement. VWHO values will be determined using a Chironomidae (Insecta:Diptera) VWHO inference model. Fish abundances will be inferred using a *Daphnia ephippia* model. The major goals of these paleolimnological analyses are: 1) to determine if a VWHO of 7 mg/L reflects the historical characteristics of the lake; 2) to determine how fish abundance has fluctuated; 3) to compare inferred changes in VWHO and fish abundance with variability in anthropogenic P inputs. *Keywords: Lake Simcoe, Fish habitat, Paleolimnology, Oxygen.*

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Knoxville, TN. **Global Gene Expression in Larval Zebrafish Exposed to Microcystis aeruginosa: More Than Just Microcystin.**

Large-scale *Microcystis* blooms occur annually in the lower Great Lakes, and microcystin concentrations often exceed the WHO advisory level of 1 µg/L. While fish kills have been associated with elevated microcystin concentrations, sublethal effects are largely unknown. We exposed zebrafish larvae to purified microcystin-LR (0-1,000 µg/L) or lyophilized *Microcystis aeruginosa* PCC7806 for 96 hours and determined effects on global gene expression (Affymetrix arrays). Relative to control, 213 genes were differentially expressed (> two-fold change) in larvae exposed to microcystin-LR. In larvae exposed to *M. aeruginosa*, 59 genes differed in expression, 26 of which were found only in fish exposed to *M. aeruginosa*. Of particular interest, genes involved in vitellogenin production were highly up-regulated in the *Microcystis* treatment (30 to 190-fold), but not induced in larvae exposed to microcystin-LR. These results suggest vitellogenin genes are not affected by microcystin-LR but some other secondary metabolite(s) produced by *M. aeruginosa*. Ongoing analysis of microarray data will provide insight into additional pathways activated by microcystin and *M. aeruginosa* and provide potential biomarker genes for assessment of fish living in *Microcystis* affected environments. **Keywords:** Fish toxins, Microcystis, Gene expression.

ROKITNICKI-WOJCIK, D. and CHOW-FRASER, P., McMaster University, 1280 Main St. W., Hamilton, ON, L8S 4K1. **Use of Logic-based Decision Tree Analysis and IKONOS Imagery to Classify Coastal High Marsh and Inland Wetland Vegetation.**

Wetlands provide numerous invaluable ecosystem services and have thus been the focus of intensive classification analyses and inventorying efforts. In an age where high-resolution remote sensing imagery has lent itself to landscape ecological studies, these emerging technologies have become increasingly valuable. IKONOS imagery has successfully been used to classify wetland vegetation; however, freshwater coastal wetlands (particularly the terrestrial portions) have received little attention. Here we use IKONOS imagery to classify wetland vegetation, focusing on coastal high marsh and inland wetlands in eastern Georgian Bay, Ontario, Canada. Vegetation was separated into 6 classes, in addition to separate classes for rock and water. A decision tree classifier with Definiens Developer 7.0 software (Definiens; München, Germany) allowed for increased thematic accuracy and the use of logic-based decision rules. The impetus of this work is to apply the classification to the creation of a detailed inventory of coastal wetlands for the eastern coast of Georgian Bay and to track changes in vegetation with water level change to aid in coastal wetland conservation. **Keywords:** Georgian Bay, Remote sensing, Coastal wetlands.

ROSSO, N.¹, WOOTTON, B.², METCALFE, C.D.³, and ANDERSON, B.⁴, ¹1600 West Bank Dr., Trent University, Peterborough, ON, K9J 7B8; ²200 Albert St., Fleming College, Lindsay, ON, K9V 5E6; ³1600 West Bank Dr., Trent University, Peterborough, ON, K9J 7B8; ⁴Dr. Bruce C. Anderson, Queen's University, Kingston, ON, K7L 3N6. **Assessing the Ability of Treatment of Wetlands to Mitigate Contaminants from Wood Waste Leachate.**
There is a growing concern and awareness about the negative effects of leaching residuals from wood waste at saw mill sites in Ontario. The proposed research project is located in Whitney, Ontario, and will be one of the first of its kind in the province. The objectives of the project are: 1) examine the sources of contaminants in leachate runoff through column testing; and 2) test the effectiveness of wetland designs. Parameters include the metals copper, zinc, and iron, and organic compounds such as tannins, lignins, and phenols. Test variables for the treatment wetland will include species of vegetation, substrate media, and abundance of dissolved oxygen through passive and forced aeration. Prior to construction of full scale treatment wetlands, column test experiments will be conducted to determine the most effective vegetation types and substrate media that will reduce concentrations of metals, and tannins, lignins and phenols to below PWQOs. Wood waste leachates can be toxic in the environment, unless treated at the source. This research will promote sustainable and effective saw mill practices through optimization of treatment wetland design and through the development of best management practices throughout this important resource industry. Keywords: Wetlands, Ecosystem health, Pollutants.

ROTHLISBERGER, J.D.¹, LODGE, D.M.¹, FINNOFF, D.C.², and COOKE, R.M.³, ¹University of Notre Dame, Department of Biological Sciences, Notre Dame, IN, 46556-0369; ²University of Wyoming, Department of Economics and Finance, Laramie, WY, 82071; ³Resources for the Future, 1616 P St., NW, Washington, DC, 20036. Ship-borne NIS Diminish Ecosystem Services of the Great Lakes: A Structured Expert Judgment Study.

We performed a structured expert judgment study on the ecological and economic impacts of ship-borne nonindigenous species (NIS) in the Great Lakes (GL). We elicited ten North American GL experts on ecosystem services affected by NIS: wildlife watching, raw water usage, and commercial and recreational fishing. A calibration method assessed each expert’s ability to characterize uncertainty probabilistically. Experts differed significantly in calibration performance, and experts' opinions indicated substantial uncertainty about NIS impacts. To generate aggregate impact assessments, with uncertainty bounds, we combined experts' judgments based on calibration performance. Aggregate results indicated that NIS-associated reductions in commercial fishing range from 10.5% (L. Erie) to 338% (L. Ontario), with a mean in the other 3 lakes of 36%. Experts estimated losses to recreational fishing at 18% over all five lakes. Average annual NIS-related expenses were estimated at $66K per raw water-using facility. Impacts are expected to grow into the future, at most doubling during our 20 yr time horizon. Our study used a novel application of expert judgment to provide the first comprehensive and bounded estimates of ship-borne NIS impacts in the GL. These results could help evaluate the net value of access to the GL by ocean-going ships. Keywords: Economic impact, Biological invasions, Ballast.

RUCINSKI, D.K.¹, BELETSKY, D.², DEPINTO, J.V.³, SCAVIA, D.², and SCHWAB, D.J.⁴, ¹LimnoTech, 501 Avis Dr., Ann Arbor, MI, 48108; ²Cooperative Institute for Limnology and Ecosystem Research, 440 Church St., Ann Arbor, MI, 48109; ³University of Michigan, School of Natural Resources, 440 Church St., Ann Arbor, MI, 48109; ⁴Great Lakes Environmental Research Laboratory, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105. Long-term Application of a Climate-driven Dissolved Oxygen Model for the Central Basin of Lake Erie.
Despite decreases in nutrient loading since the 1970s, Lake Erie continues to experience hypoxia (dissolved oxygen < 2 mg·L⁻¹) during the period of summer stratification, particularly in the central basin hypolimnion. Several environmental factors are thought to drive the timing and magnitude of hypoxia, including climatology, cultural eutrophication, and invasive species. Here, we examine the effects of the thermal cycle (i.e., climatology) of the lake with a long-term application (1987-2005) of a simple model to estimate dissolved oxygen (DO) in the central basin. A 1-dimensional vertically segmented hydrodynamic model provides the thermal structure of the central basin. DO is lost from the water column due to a parameterized volumetric loss rate and a sediment oxygen demand is applied in the bottom layer. A long-term time series of model-determined oxygen loss rates is examined for its relationship to thermal stratification conditions and phosphorus loading. Keywords: Lake Erie, Oxygen, Ecosystem modeling.

RUCINSKI, D.K.¹, BELETSKY, D.², DEPINTO, J.V.¹, SCAVIA, D.³, and SCHWAB, D.J.⁴, ¹LimnoTech, 501 Avis Dr., Ann Arbor, MI, 48108; ²Cooperative Institute for Limnology and Ecosystem Research, 440 Church St., Ann Arbor, MI, 48109; ³University of Michigan, School of Natural Resources, 440 Church St., Ann Arbor, MI, 48109; ⁴Great Lakes Environmental Research Laboratory, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105. Development and Application of 1D Eutrophication Models for the Central Basin of Lake Erie.

Hypoxia (dissolved oxygen < 2 mg·L⁻¹) in the central basin of Lake Erie has reemerged as a hazard to ecosystem health, despite reductions in nutrient loading required by the Clean Water Act. Several studies are being conducted to investigate the causes of hypoxia in Lake Erie, which may include climatology, cultural eutrophication, and invasive species. Two eutrophication models were developed to predict primary production and the associated oxygen dynamics for the period of 1987-2005. The first model is a simple stoichiometric algal growth model based on in-lake phosphorus concentrations and incident light. The second model expands on the first by incorporating grazing and detritus pools. Both models are linked to a 1-dimensional vertically segmented thermal model for temperature and transport inputs. The model results are compared to previous dissolved oxygen modeling applications. Keywords: Ecosystem modeling, Lake Erie, Eutrophication.

RUKHOVETS, L.A.¹, ASTRAKHANTSEV, G.P.¹, MENSHTUKIN, V.V.¹, MININA, T.R.¹, PETROVA, N.A.², and POLOSKOV, V.N.¹, ¹ul. Chaikovskogo 1, St. Petersburg, 191187, Russian Federation; ²ul.Sevastyanova 9, St. Petersburg, Russian Federation. The Influence of Climate Changes and Anthropogenic Loading on the Lake Ladoga Ecosystem.

The estimates of possible changes in the lake circulations and temperature regime of Lake Ladoga are obtained. To achieve this, round-the-year circulations were simulated under varying external forcing and water inflow. With use of the 3-D hydrodynamic model developed by the authors earlier, several different types of the lake circulations that correspond to possible changes in the climate were calculated. The analysis of results shows that changes in the lake circulations to the middle of the XXI century can be considered as negligible. The changes in the lake ecosystem can be considered as the integral estimates of changes in the lake circulations. To evaluate the ecosystem changes, the authors have simulated the year-round functioning of the lake ecosystem for different circulations under several different external loading.
as well as for different scenarios of loading change in the long-term perspective. The most important result of this study performed: the key factor that determined the state of Lake Ladoga is the level of anthropogenic loading. Results obtained in these investigations can be used for choosing the policy of sustainable development and management of water resources of this lake. This study is supported by the Russian Fund of Basic Research (projects 06-06-80240, 06-06-08008). Keywords: Climate change, Lake model, Plankton.

RUTHERFORD, E.S.¹, TYLER, J.A.², WILEY, M.J.¹, RISENG, C.M.¹, HYNDMAN, D.³, and PIJANOSWKI, B.C.⁴, ¹Institute for Fisheries Research, Cooperative Institute for Limnology and Ecosystems Research, School of Natural Resources and Environment, Dana Bldg., 440 Church St., Ann Arbor, MI, 48109-1041; ²Fisheries Projections, 307 Old Mountain Rd., Farmington, CT, 6032; ³Department of Geology, 206 Natural Science Bldg., Michigan State University, East Lansing, MI, 48824-1115; ⁴Department of Forestry and Natural Resources, Purdue University, 715 West State St., W. Lafayette, IN, 47907-2061. Effects of Urban Development in the Muskegon River Watershed on Growth, Survival, and Potential Recruitment of a Lake Michigan Steelhead Population: Results of a Multi-modeling Approach.

We examine how rates of urban development and reforestation in the Muskegon River watershed affect age-0 steelhead populations with a multi-modeling system. Basin-wide land use change and hydrologic models forecast alterations in the ecosystem’s water budget. Local-reach hydraulic models provide a high-resolution, spatially-explicit depiction of the physical environment that we combine with site-specific data to model the biological environment. Our individual-based model (IBM) operates in this model environment and follows steelhead from spawning until the end of the first growing season in early October. The IBM includes mechanistic submodels which simulate steelhead foraging, growth, movement, and mortality resulting from predation, starvation, and substrate scouring or siltation. We run the IBM for landscapes representing years 1998, 2010, 2020, 2040, 2070, and 2100 under land use scenarios reflecting: 1) expected urban development (baseline), 2) urban development under a “slow growth” regime, and 3) baseline with reforestation. IBM simulations show changes in survival, density, size, and potential recruitment of age-0 steelhead under the three different urban development scenarios. Keywords: Computer models, Recruitment, Watersheds.

RYAN, P.A.¹ and MACDOUGALL, T.M.², ¹Villa Nova Estate Ltd., RR4 (1449 Con. 13), Simcoe, ON, N3Y 4K3; ²Ministry of Natural Resources, PO Box 429, Port Dover, ON, N0A 1N0. Habitat Objectives to Support Rehabilitation of Percids in Lake Effect Zones of Lake Erie and Detroit R. Corridor.

Most rivers tributary to Lake Erie or the Detroit River corridor have lake effect zones or “lacustuaries” with extremely degraded habitat, which limits recovery and production of localized walleye and yellow perch stocks. High nutrient concentrations combined with seasonal low flows during summer and fall result in abundant algal growth, turbidity, low dissolved oxygen, and degraded wetlands. Adverse temperatures occur seasonally (winter/summer) while adverse TSS events are associated with storms and snow-melt. The term “good habitat” needs to be translated into numbers in order to establish targets for rehabilitation of habitat for perch and walleye. We review literature values for effects of suspended
solids/turbidity, temperature and dissolved oxygen on fish, in reference to field observations. We develop habitat objectives, with seasonal and spatial or “refuge” aspects. Specialized monitoring programs are required in order to collect data required to assess the status of habitat, and progress in rehabilitation. Fish stock recovery will be a visible indicator, that will track recovery of habitat and the entire aquatic community. *Keywords: Habitats, Walleye, Yellow perch.*

RYMAN, J.E.¹, KOOPS, M.A.², and POWER, M.¹, ¹University of Waterloo, 200 University Ave. West, Waterloo, ON, N2L 3G1, Canada; ²Department of Fisheries and Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6, Canada. **Spatial and Temporal Analysis of Hamilton Harbour Food Web Components using δ15N and δ13C.**

Stable isotopes (δ13C, δ15N) will be used to determine food web interactions spatially and temporally in Hamilton Harbour. Plankton, benthic invertebrates, and fish were sampled in spring, summer, and fall in 3 regions of the harbor (east, west, and north shores). Seasonally, the 3 sites follow the same patterns for δ15N in both phytoplankton and zooplankton, a gradual decrease from spring to summer and increasing again in fall. Zooplankton δ13C for all three sites followed similar patterns with the most enriched carbon signatures appearing in early August, the same time period as the depleted nitrogen peak. The δ13C of phytoplankton was much more variable, possibly as a result of variations in input sources to the harbor. The east end of the harbor is influenced by Lake Ontario as well as the discharge of wastewater from the cities of Hamilton and Burlington. The west end of the harbor is much more sheltered, but subject to inputs from Cootes Paradise (with two wastewater treatment plants discharging into it) and Grindstone Creek. Analysis of fish δ13C and δ15N signatures is discussed against the background of observed variations at the base of the food web with particular attention paid to spatial differences within and among seasons. *Keywords: Carbon, Stable isotopes, Food chains.*

SANDERS, T.G.¹, BIDDANDA, B.A.¹, KENDALL, S.T.¹, STRICKLER, E.A.¹, OSTROM, N.E.², STRICKER, C.A.³, and NOLD, S.C.⁴, ¹Annis Water Resources Institute, Grand Valley State University, Muskegon, MI, 49441; ²Department of Zoology, Michigan State University, East Lansing, MI, 48824-1115; ³U.S. Geological Survey Stable Isotope Lab, DFC Bldg. 21, MS 963, Denver, CO, 80225; ⁴213 Science Wing -- Jarvis Hall, University of Wisconsin -- Stout, Menomonie, WI, 54751-0790. **An Ecological and Stable Isotope Study of Food Web Linkages in Submerged Vent Ecosystems of Lake Huron.**

The Great Lakes region is underlain by a series of aquifers with substantial runoff occurring through groundwater flow. In western Lake Huron, there are several submerged vents that discharge groundwater plumes with high dissolved sulfate and extremely low dissolved oxygen. Recent studies of some sinkholes have shown them to be microbially dominated biogeochemical hotspots of intense photosynthetic and chemosynthetic production of organic matter. Traditional ecological techniques show distinct distributions of organisms inversely correlated to the distance from groundwater input. New data from stable isotope analyses of 13C, 15N, and 34S show the groundwater to have a unique stable isotope signature when compared to surrounding lake environments. This source signature can be used to trace energy flow from producers (benthic algae, plankton) to consumers (macroinvertebrates, fish).
Preliminary data suggest that, on average, benthic bacterial/algal mats were -8.9‰ and invertebrates were -12.88‰ more 13C depleted at sinkholes versus lake controls. Furthermore, invertebrate feeding benthic fish carry a lighter signature than the more mobile predatory fishes. Continuing analyses will test the notion that sinkhole vents are not only zones of increased local production but are also important to the surrounding lake ecosystem. Keywords: Food chains, Stable isotopes, Lake Huron.


The usefulness and function of areas protected from fishing has been a major issue of scientific as well as political debate over the last decade. With a few exceptions, the vast majority of both case-studies and theoretical models on protected areas are from tropical marine environments. Although fisheries management in lakes to some extent faces similar problems as in marine systems, fishery closures have rarely been used as a management method. Subsequently, the numbers of studies from lakes are few and rather limited. We provide an example of early results from an assessment of fishery closures in Swedish Lake Vättern, the fifth largest lake in Europe. The commercial catch of the important fish species; whitefish (Coregonus lavaretus, L.) and Arctic char (Salvelinus alpinus, L.) have declined markedly since the mid 70’s and as a means of remediation, three large areas, comprising 15 % of the lake’s surface, were closed for all fishing in 2005. We report the results from a monitoring program following the response of both the pelagic as well as the benthic fish communities within and outside the protected areas. Two years after the closure, the overall catch per unit effort of both target species has increased. However, only minor differences between closed areas and fished areas could yet be observed. Keywords: Fisheries, Assessments, Fish management.

SATCHWELL, M.F., HOTTO, A.M., and BOYER, G.L., State University of New York, College of Environmental Science and Forestry, 1 Forestry Dr., Syracuse, NY, 13210. Using the Microcystin mcyA Gene to Track Toxin Movement in Northern Lake Champlain.

In Missisquoi Bay, the northeastern arm of Lake Champlain, the cyanobacterial toxin microcystin annually reaches levels which exceed the WHO guideline value for drinking water. Concentrations of 5 ppb in open water and greater than 30 ppb in surface scums are common. Six years of whole lake monitoring (2000-2005) indicated that this highly eutrophic bay may serve as the source of microcystin to other regions of the lake. Previous work using PCR to detect a suite of microcystin synthesis genes has shown that the number of positive microcystin amplicons decreases with distance from Missisquoi Bay. During the summers of 2006 and 2007, samples for DNA analysis, microcystin quantification and pigment concentration were collected from Missisquoi Bay, south through the Inland Sea (eastern basin of Lake Champlain) and down through the Alburg passage connecting Missisquoi Bay to the northwest section of the lake (northwest arm). Cyanobacteria were dominant or co-dominant at all stations. Measurable amounts of microcystin were found at most stations. PCR indicated that Microcystis was present at most stations, as were the 2 toxin biosynthesis genes mcyA and mcyD. The movement of
potentially toxin-producing populations was estimated from genotype compositions, determined by sequencing the \textit{mcyA} amplicon. \textit{Keywords:} Microcystis, Toxic substances, Lake Champlain.

\textbf{SAXTON, M.A.} \textsuperscript{1}, TRUITT, D.B. \textsuperscript{1}, MCKAY, R.M.L. \textsuperscript{2}, BOURBONNIERE, R.A. \textsuperscript{3}, and WILHELM, S.W. \textsuperscript{1}, \textsuperscript{1}Department of Microbiology, University of Tennessee, Knoxville, TN, 37996; \textsuperscript{2}Department of Biological Sciences, Bowling Green State University, Bowling Green, OH, 43403; \textsuperscript{3}Environment Canada, Canada Centre for Inland Waters, Burlington, ON, L7R 4A6. \textbf{Defining the Role(s) of Phosphorus in Promoting Toxic Cyanobacterial Blooms.}

Phosphorus (P) speciation plays a defining role in determining freshwater phytoplankton community structure. A noteworthy fraction of the total P in the Great Lakes is present in organic forms (i.e., phosphonates, phospholipids, and nucleic acids) from agricultural runoff, viral lysis, and other sources represent important inputs of P into the Great Lakes. Also, organic phosphorus has been shown to be important in the ecology of the marine cyanobacterium \textit{Trichodesmium} spp. With this in mind we hypothesized that organic phosphorus would influence the phytoplankton community structure in Sandusky Bay, Lake Erie, USA. Sandusky Bay is a site of annual blooms of the toxic cyanobacterium \textit{Planktothrix} spp. In lab studies we tested the ability of \textit{Planktothrix} spp. to use glyphosate (a phosphonate) as a P source. Lab experiments were complimented by field studies and microcosm incubations using Sandusky Bay water to examine the effects of glyphosate on natural phytoplankton communities. Our findings indicate that \textit{Planktothrix} spp. can use glyphosate as a phosphorus source and that glyphosate also influences the development of phytoplankton communities in bay water microcosm incubations. \textit{Keywords:} Harmful algal blooms, Lake Erie, Glyphosate.

\textbf{SCOTT, B.F.}, SPENCER, C., LOPEZ, E., and MUIR, D.C.G., Canada Centre for Inland Waters, 867 Lakeshore Rd., Burlington, ON, L7R 4A6. \textbf{PFAs in Lakes Erie and Superior and Their Tributaries.}

Perfluoroalkylacids (PFAs), including perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS), belong to a family of chemicals that are very persistent in the environment. They are under scrutiny by government agencies who must determine their risk to the general population and to the environment. Several studies have shown that PFOS and other PFAs are present in biota and surface waters of the Great Lakes. We have focused on two of the Great Lakes, Erie and Superior, conducting special and temporal distribution of PFAs in the water column. In addition, the PFA content of their tributaries was measured to determine their influence on the whole lake concentrations. Finally, the PFA concentrations at 3 points along the St. Lawrence River were determined. Lake Superior profiles and other exhibited <1 ng/L for both PFOA and PFOS at each site. This is reflected in the content of these compounds in 6 tributaries. Lake Erie had PFOA and PFOS concentrations > 2 ng/L throughout the water column and the tributaries also had comparable elevated concentrations. In Lake Huron PFOA and PFOS concentrations were >1 and < 4 ng/L while the St. Lawrence River results for both compounds were > 4 ng/L. \textit{Keywords:} Perfluorooctane sulfonate, Tributaries, Great Lakes basin.
SEALOCK, L. and WELLS, M.G., DEPS, UTSC, University of Toronto, 1265 Military Trail, Toronto, ON, M1C1A4. **Residence Timescales and the Underlying Hydrodynamic Processes in Frenchman’s Bay, a Lake Ontario Coastal Embayment.**

We explore the links between residence timescales and the underlying hydrodynamic processes in Frenchman’s Bay, a coastal lagoon that is permanently connected to Lake Ontario through a narrow and shallow channel. Exchange between the bay and the lake is the result of thermal variations, oscillations in water level and wind. This study uses water level time series, and water physico-chemical data to characterize the residence time for Frenchman’s Bay. One-half the daily sum of water level increments is directly interpretable as the depth of water column affected by all seiche activity. This metric is used to estimate the seiche-induced exchange flow rate. Inviscid exchange flow rate is calculated to estimate a residence time based on temperature-induced flow. Taking into consideration the effects of both temperature and seiche-induced exchange flow, we calculate a total residence time within Frenchman’s Bay of 7.5 days ± 1 day. Assuming a steady state in the salinity of the bay, we calculate a second residence time based on salinity differences between the bay and Lake Ontario, using data of the annual salt flux into the bay. This generates a residence time of 8.3 days ± 1 day. Data provided will support future efforts to understand seiche and water temperature influences on Great Lakes embayments. **Keywords:** Water currents, Coastal wetlands, Water level fluctuations.

SEEFELT, N.E., Department of Biology, Central Michigan University, Mt. Pleasant, MI, 48859. **Comparing Decadal Census Trends and Yearly Variation in the Abundance and Distribution of Breeding Double-crested Cormorants: The Importance of Monitoring a Managed Species.**

Decadal waterbird censuses began in 1976, and have been repeated every eight to ten years in U.S. waters. Between 2000 and 2007, cormorants were monitored in the Beaver Archipelago. During this time, there were no official population controls of these birds, with the exception of culling 150 birds for stomach content analysis in 2000 and 2001, and an egg-oiling and culling program in 2007. Yearly variation in the breeding population size, clutch size, and reproductive output was documented. The peak number of breeders was in 1997; in 2007, as compared to the more recent counts, the number of birds increased in the archipelago, suggesting immigration from other regions. Yearly surveys found that individual colonies showed great plasticity, with some colonies forming and others disappearing. Although some of these changes appear to be due to environmental factors, others indicate interactions with other species (both avian and mammalian), human disturbance, and perhaps management actions in other areas. Yearly population estimates indicate that the long-term trends are probably captured with decadal waterbird surveys, but the dynamic nature of cormorant populations is not. Variation in the breeding population size an “unmanaged” population stresses the importance of closely monitoring species that are aggressively managed. **Keywords:** Cormorants, Decadal census, Lake Michigan, Populations.

SEEFELT, N.E. and SHAW, H.L., Department of Biology, Central Michigan University, Mt. Pleasant, MI, 48859. **Initial Development of an Avian Monitoring Site at the Central Michigan University Biological Station on Beaver Island.**
The USFWS has prioritized objectives for avian conservation, including guidelines for neotropical migrants. Stopover ecology is one aspect of their biology where information is lacking. This research examines the potential importance of the CMU Biological Station shoreline property as a stopover site by focusing on the spatial and temporal distribution of migrants at this site, the species-specific use of this site, and the physical condition of birds utilizing the site by employing standard methods in landbird monitoring. Because of the island’s location in the open waters of Lake Michigan, it may provide habitat that is critical to migrating birds. In 2006, fifty three avian species were documented during spring migration at this location; of these, twenty neotropical migrant species were recorded. Eight of these species are recognized by the PIF American Landbird Conservation Plan and/or the USFWS Conservation Priorities as species of concern. In 2007, several more neotropical migrants, as well as other species, were been documented through a mist netting program; several of these species were not detected by sight and song censuses. These data will aid in the development of this unique location as a center for avian monitoring, and in advancement of conservation and management plans for these birds and their habitats.

Keywords: Avian ecology, Stopover ecology, Lake Michigan, Neotropical migrants, Migrations.


Water quality of the Great Lakes 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. This study reports polybrominated diphenyl ethers (PBDEs) in surficial sediments of Lakes Superior, Huron, and Michigan. Sediment samples were collected at locations in the open waters, nearshore waters, and Canadian tributaries of the lakes. PBDEs were detected in all sediment samples in the range of 1.2 to 53 ng/g dry wt. High PBDE concentrations were found at several tributary sites of Lakes Superior and Huron. PBDEs in open water and nearshore water sediments had lower concentrations, which were at the lower end of the PBDE concentration range reported in the literature. BDE209 was the most abundant congener in sediments, occurring in over 90% of samples. BDE 47 and 99 were also detectable in most samples, followed by BDE100, 153, 154, and 183. Sediment samples with high PBDE concentrations had congener-specific patterns that are different from a typical pattern of atmospheric deposition and varied with sampling locations, implying that industrial activities near the Great Lakes contribute to PBDE contamination in sediments. Keywords: PBDEs, Great Lakes basin, Sediments.


Cultural eutrophication has affected Severn Sound, a region in southeastern Georgian Bay, since the 1960s. In 1985, this region was identified as an Area of Concern by the International Joint
Commission due to excessive algal growth. A remedial action plan was developed starting in 1986 with the final plan (Stage 2 Report) completed in 1993. The RAP included a phosphorus control strategy and habitat restoration and enhancement to encourage a restored balance to the fish community. Other actions included remediation of pollution sources to beaches and pollution measures. Substantial completion of the remedial actions with conditions to follow up where needed was reported on in the Stage 3 Report which was accepted by the federal and provincial governments in 2003. Since that time monitoring has continued to track trends with time and stewardship actions in the watershed have been pursued. This paper will provide an update of the status of the former AOC. Keywords: Remediation, Ecosystems, Eutrophication.


As part of a broader assessment of wildlife health in Great Lakes Areas of Concern (AOC) we are examining wild and caged fish for evidence of exposure to environmental estrogens (EEs) and possible anti-estrogens. We divided the St. Clair River into upstream, impact zone, and downstream sites. At each site we captured adult male and female specimens of pelagic and benthic species. We also caged juvenile rainbow trout (*Oncorhynchus mykiss*) at each site in both rivers. The presence of vitellogenin (Vg) in the plasma of male or juvenile fish is indicative of exposure to EEs. A decrease in the concentration of plasma Vg in female fish, when compared with females from the reference location, could indicate exposure to anti-estrogens, although other explanations are possible. The data suggest that wild fish at the St. Clair River AOC have had exposure to EEs. Moreover, Vg concentrations in the plasma of female shorthead redhorse sucker (*Moxostoma macrolepidotum*) from the impact zone were less than in females from the reference site (\(p = 0.04\)). Vg was induced in fish caged in Sarnia Harbour on the St. Clair River, but was not strongly induced at the other sites. Pelagic and bottom dwelling fish in these two rivers may experience different EE exposures. Keywords: Ecosystem health, Fish, Endocrine disruption.

SHRESTHA, D.¹, WOOTTON, B.², and METCALFE, C.D.³, ¹1600 West Bank Dr., Watershed Ecosystems Graduate Program, Trent University, Peterborough, ON, K9J 7B8, ²200 Albert St., Centre for Alternative Wastewater Treatment, Fleming College, Lindsay, ON, K9V 5E6, Canada; ³1600 West Bank Dr., Environmental and Resource Studies Program, Trent University, Peterborough, ON, K9J 7B8. The Effects of Temperature and Plants in Simulated Arctic Treatment Wetland.

There has been a growing concern in understanding the effects of temperature and plant species in treating contaminants using a treatment wetland. The early studies suggest low performance of carbon and nitrogen removal to low temperature owing to low microbial growth rates. However, recent studies have shown removal efficiencies of organic matter (BOD, COD) may not be temperature dependent. The low temperature may not necessarily relate to low performance of the system. Further, studies suggest physiological response of some plant species to seasonal dormancy and lower temperature may permit increased oxygen transfer to the root zone of a subsurface constructed wetland. A number of factors ranging from hydraulic retention time to type of wastewater, grain size of a substrate, presence of oxygen,
and species selection will determine performance of the system. This research focuses on the study of treatment efficiencies of wastewater through simulation of Arctic conditions. The in-situ column experiments are carried out between -20 to +35°C with plant species common to Arctic. The physicochemical and microbiological analyses will help in understanding temperature variability and its interaction with various parameters in treating wastewater which is crucial for an effective design and application in an Arctic environment. Keywords: Arctic, Experimental design, Wetlands.


An algorithm has been developed by Michigan Tech Research Institute (MTRI), Nansen International Environmental and Remote Sensing Center (NIERSC), and NOAA Great Lakes Environmental Research Laboratory (GLERL) that is capable of retrieving concentrations of chlorophyll (CHL), dissolved organic carbon (DOC), and suspended minerals (SM) from satellite images of coastal and inland waters. The algorithm employs a water-body specific hydro-optical model, which is a set of backscattering and absorption coefficients for CHL, DOC, and SM, to estimate concentrations of these substances. To generate the water body specific hydro-optical model for the Great Lakes, a set of dedicated field sampling campaigns was conducted in 2005-2007. Using a Satlantic profiling radiometer, we collected in-situ irradiance and radiance values at bands corresponding to the MODIS and SeaWiFS satellite sensors, as well as sea truth data for CHL, DOC, and SM. In 2005 we obtained extensive observation in Lake Erie while in 2006 and 2007 optical properties in Lakes Huron and Superior were obtained. Results of the model show a strong correlation between in-situ and retrieved CHL and SM. Keywords: Remote sensing, Lake model, MODIS.

SHUCHMAN, R.A.1, MEADOWS, G.A.2, and LIVERSEDGE, L.K.1, 1Michigan Tech Research Institute, 3600 Green Court, Suite 100, Ann Arbor, MI, 48105; 2University of Michigan, 126 West Hall, 1085 South University, Ann Arbor, MI, 48109. Automated Lagrangian Water-quality Assessment System (ALWAS).

ALWAS is a relatively inexpensive, free-floating, sail-powered or jet-driven water quality measuring and watershed evaluation buoy. It is capable of measuring a data point in a water body with multiple parameters as rapidly as every 40 seconds. Data are transmitted for real-time viewing and are stored for future retrieval and analysis. The stored data are easily downloaded into geographic database (ESRI shapefile) and spreadsheet formats. ALWAS uses state-of-the-art sensors to measure water quality parameters and GPS data. The buoys presently measures depth, temperature, conductivity, salinity, total dissolved solids, dissolved oxygen, pH, oxidation-reduction potential, turbidity, chlorophyll-a, blue-green algae, nitrates, ammonium, and chlorides. ALWAS has been successfully deployed in Lake Michigan,
Lake Superior, tributary rivers of the Great Lakes, inland lakes in Michigan and Ohio, at the Bering Glacier in Alaska, and on the North Slope of Alaska. ALWAS has also been used to validate and help create remote sensing-based aquatic models and algorithms. *Keywords: Water quality, GIS, Data acquisition.*

SHUTT, J.L.¹, WESELOH, D.V.², PEKARIK, C.², MOORE, D.², and WILLIAMS, K.L.², ¹Environment Canada, National Wildlife Research Centre, 1125 Colonel Bay Dr., Ottawa, ON, K1A 0H3; ²Environment Canada, Canadian Wildlife Service, 4905 Dufferin St., Toronto, ON, M3H 5T4. **Impacts of Exposure to Type E Botulism on the Health of Colonial Waterbird Populations in Eastern Lake Ontario.**

Type E botulism was first recorded in birds in the Great Lakes in the early 1960s and was not documented in colonial waterbirds in Lake Ontario until 2002. Since then, epizootics of type E botulism involving gull and tern species as well as double-crested cormorants (DCCOs) have occurred annually. Following a significant die-off during the summer of 2004, we initiated regular colonial waterbird surveys during the fall of 2004 and again in 2005 and 2006 to document mortality in fish-eating birds associated with type E botulism. Numbers of dead birds recovered were related to local population size. In 2004-2006 6 island nesting colonies in eastern Lake Ontario were surveyed 3 times per month between the July and November. During the 3 years surveyed 4,725 dead colonial waterbirds were recorded consisting of 3,329 (70% of total) DCCOs, 642 (14%) ring-billed gulls, 386 (8%) herring gulls, 248 (5%) great black-backed gulls (GBBGs), and 95 Caspian terns (2%). The remainder (1%) consisted of shorebird and waterfowl species. Colonies with the highest mortality changed from year to year. Since 2002 populations of great black-backed gulls in the eastern basin of Lake Ontario declined by 90%, indicating a possible population-level impact of type E botulism on this species. Impacts on other colonial waterbird species will be discussed. *Keywords: Invasive species, Disease, Avian ecology, Colonial waterbirds, Lake Ontario.*

SIMPSON, H.¹, BRADLEY-MACMILLAN, C.¹, MYSLIK, J.P.¹, and TAYLOR, E.P.¹, ¹Ontario Ministry of Agriculture, Food and Rural Affairs, 1 Stone Road West, Guelph, ON, N1G 4Y2; ²University of Guelph, Department of Geography, Guelph. **The Ontario Environmental Farm Plan - A Case Study of a Successful Community Water Resource Stewardship Program.**

Community interest and involvement is a significant component of successful water protection programs. It is significant because changing daily activities around the business, farm, or home is more effective in protecting water resources than the most comprehensive strategy. Unfortunately, most water resource protection programs limit awareness and education to the traditional community consultation approach. The traditional approach typically involves talking to the community about the importance of water resources, but does little to help community members understand how they can help make a difference. An alternative approach is to view the rural community as a group of potential partners who can make a difference by changing their daily activities around the business, farm or home. This involves working with stakeholders to develop a program cooperatively that will help the community to understand both the concern and ways that they can change their business, farm and household activities that will help protect water resources. This paper presents a case study using Ontario’s Environmental Farm Plan...
to demonstrate how this alternative approach can be used. An education and risk assessment tool that assists farmers to select best management practices for protecting water resources will be discussed.

**Keywords:** Risk assessment, Education, Stewardship.

**SKINNER, A.J.** 1, **EVANS, D.O.** 1, **ALLEN, R.** 2, and **MCMURTRY, M.** 3, 1Ontario Ministry of Natural Resources, Trent University, 2140 East Bank Dr., Peterborough, ON, K9J &B8; 2Ontario Ministry of Natural Resources, 50 Bloomington Road, Aurora, ON, L4G 3G8; 3Ontario Ministry of Natural Resources, 300 Water St., Peterborough, ON, K9J 8M5. In**vasion History of Zebra Mussels in Lake Simcoe.

Adult zebra mussels, *Dreissena polymorpha*, were first observed in Lake Simcoe on a boat hull in 1991. In 1994 and 1995, we used multiple-plate tower samplers at six locations to detect settlement of veligers. The samplers were suspended about 3 m below the lake surface over a depth of 6 m. Low densities of settled veligers were observed during summer 1994 (0-1,742 m²). The abundance of settlers in 1994 was greatest at sites in the main basin. Densities were much lower in Kempenfelt Bay (KB), Cooks Bays (CB), and Lake Couchiching (LC). In 1995, the number of settlers increased by two orders of magnitude at the main basin sites(165,343-173,848 m²), and densities in KB, CB and LC (8,990-17,114) exceeded the highest densities observed in 1994. Adult zebra mussels were not found during an intensive lake-wide survey of rocky shoals in the summer 1993. Low densities of adults were initially observed on rocky substrates in the fall of 1994 and the winter of 1995. In February 1996, two distinct adult year classes of zebra mussels were found on shoals at the north and south ends of the lake. Densities of adults averaged 68,239 m² (31,159-105,890) in 1996 indicating widespread colonization and high densities on rocky littoral zone substrates. **Keywords:** Invasive species, Zebra mussels, Lake Simcoe.

**SMITH, L.A.** and **CHOW-FRASER, P.**, McMaster University, 1280 Main St. W., Hamilton, ON, L8S 4K1. **Monitoring Wetland Birds in Great Lakes Coastal Marshes.**

Concern over the recent decline in many wetland-dependent bird species has led to an investigation into human land use practices and the potential role they play in this decline. In order to determine the effects humans are having on wetland birds, accurately monitoring bird populations is essential. We conducted point counts and vegetation surveys at 21 coastal wetlands in the Great Lakes Region from 2006-2007. Our main objectives were to determine 1) the effect of interior versus edge point counts in detecting wetland birds and 2) the efficiency of call-response broadcasts in detecting secretive wetland-dependent birds. There was no difference in the abundance of generalist marsh-nesting birds between interior and edge counts, but we found significantly more generalist marsh-nesting species at the edge. We found no significant difference between the abundance and richness of wetland-dependent birds between interior and edge counts, although interior point counts always detected more species and more individuals. Call-response broadcasts detected significantly more species and individuals than passive point counts. These results have important implications for wetland bird monitoring programs, future scientific studies, and Great Lakes wetland conservation action plans using birds as indicators of wetland quality. **Keywords:** Avian ecology, Coastal wetlands, Monitoring.

Early life stages of fish (eggs, larvae and juveniles) have high but variable growth and mortality rates, which contribute to inter-annual variation in recruitment (addition of young fish to the reproductive or fishable population). Physical events and conditions have been shown to be important to early life growth and survival in marine fish populations, through direct and indirect pathways (e.g., larval advection relative to prey distributions, physical fronts reducing access to prey or refugia from predators). Here we review physical processes common to large lakes that may have important influences on freshwater fish recruitment. We present examples of evidence for physical forcing of recruitment in Laurentian Great Lakes fish populations and of progress in modeling and other tools for studying the interactions between populations and physical forces. From these observations we seek to formulate key questions and avenues of investigation toward an overall theory of physical-biological coupling and its role in large lake fish population dynamics. **Keywords:** Fish, Hydrodynamics, Recruitment.


The Ponto-Caspian round goby *Apollonia melanostoma* invaded the Lake St. Clair region in 1990 via ballast water. It quickly spread throughout the Great Lakes and is now one of the most abundant benthic fishes in the lower Great Lakes. The objective of this study is to test whether the genetic composition of the exotic population has remained the same from place to place and over the time course of the invasion. We sequenced the mitochondrial cytochrome b gene and analyzed eight newly-developed nuclear microsatellite loci to test for spatial and temporal patterns. We analyzed 397 individuals from 2-3 time periods (1993 to 2007) at 5 locations in Lakes St. Clair, Erie, and Michigan. The cytochrome b gene has shown little temporal change and some spatial divergences. Microsatellite analyses, however, have shown a significant temporal change in Lake Michigan from 1998 to 2007. The Lake St. Clair River site, the site of the original introduction, has not appeared to have temporally changed, whereas there has been some change in Lake Erie. The original introduction site thus has been genetically stable, whereas more peripheral sites have changed over the time course of the invasion. In addition, there is spatial genetic structure among the different locations, likely reflecting differential introduction histories. **Keywords:** Round goby, Genetics, Invasive species.

SOUCY, G.¹, JOLLIET, O.², DETTLING, J.³, MARGNI, M.¹, HUMBERT, S.⁴, MANNEH, R.¹, and DESCHÊNES, L.¹, ¹Chemical Engineering, École Polytechnique de Montreal, 2900 Édouard-Montpetit, C.P. 6079, Succ. Centre-ville, Montreal, QC, H3C 3A7; ²School of Public Health, University of Michigan, Ann Arbor, MI; ³Great Lakes Commission, Ann Arbor, MI; ⁴Engineering and Project
Management, University of California, Berkeley, CA. **Evaluating the Potential Health Impacts of Multi-compound Emissions within the Great Lakes – St. Lawrence Region.**

A method is presented to weigh emissions based on their potential health impacts. It is common to use Toxic Equivalency Factors (TEF) to compare emissions of compounds such as dioxins/furans and PAH. Based on dose-response experiments, TEF are adequate to compare intake, but are often used inappropriately to produce TEF-weighted emissions. Here, to relate emissions to intake, a multi-scale multimedia fate and exposure model is being developed for the Laurentian Great Lakes region to determine Intake Fractions (the fraction of an emission taken in by the overall population). For PAH, it shows that 3% of the emitted mass correspond to 53% of the human exposure and to 98-99% of the toxic impact on humans. Hence, it is essential to account for both toxic potential and environmental transport/exposure (i.e., intake fraction) to properly weight PAH emissions. The model presented here can be used to identify sources and chemicals with a high impact in a particular area, and gains in terms of human health from a reduction in emissions. Goals for ecosystem management frameworks such as the GLWQA could be set and tracked based on the total impact of a wide range of chemicals, rather than on a chemical-by-chemical basis. An example is given with 16-PAH in the GL region. This method could potentially be applied to any set of chemicals. **Keywords: Human health, Emissions impact, PAHs.**

STAINSBY, E.A.1, WINTER, J.G.1, and PATERSON, A.M.2, 1Ontario Ministry of the Environment, 125 Resources Road, Etobicoke, ON, M9P 3V6; 2Dorset Environmental Science Center, P.O. Box 39, Bellwood Acres Road, Dorset, ON, P0A 1E0. **Trends in the Thermal Dynamics of Lake Simcoe from 1971 to 2007.**

Lake Simcoe is the sixth largest inland lake in the province of Ontario, Canada and represents a significant recreational value to central Ontario. While the impact of rapid urbanization on the nutrient status of the lake has been a primary focus of water quality research, the additional role of recent climate change has not been evaluated. In an analysis of the ice dynamics on Lake Simcoe from 1853 to 1995, Futter (2003) found a statistically significant monotonic increase in the duration of the ice-free season with a marked increase the last two to three decades. In our study we will examine lake temperature profiles at eight deep water stations in Lake Simcoe to evaluate changes in the lake from 1971 to 2007. We will also assess long-term trends in lake stability as an indicator of lake turnover given its importance in structuring biological communities within lakes. We anticipate that thermal stratification may have occurred earlier in the spring as a result of rising air temperatures (Jones et al. 2006) and earlier ice-off dates (Futter 2003). **Keywords: Climate change, Lake Simcoe, Lake temperature.**

STAINTON, M.P.1, MCCULLOUGH, G.K.2, HESSLEIN, R.H.1, and PAGE, S.J.1, 1Department of Fisheries and Oceans Freshwater Institute, 501 University Crescent, Winnipeg, MB, R3T 2N6; 2University of Manitoba, Department of Geography Centre for Earth Observation Science, Winnipeg, MB. **Effects of Climate Change on Phosphorus and Nitrogen Loading to Lake Winnipeg.**

The past decade has seen a significant increase in the size and frequency of cyanophyte blooms in Lake Winnipeg along with consequent hypoxia, algal toxins, fouled beaches, and general changes in the
food web. While these changes have for the most part been attributed to increased anthropogenic loading from municipal and agricultural sources, climate related events appear to have had a greater and more immediate impact. In this presentation we report on observed and modeled changes to lake surface temperature, precipitation patterns in the basin, and consequent modeled changes in riverine loadings of P and N to Lake Winnipeg. The nutrient loading model we have used to estimate in lake concentrations is also used to demonstrate the effectiveness of various initiated and proposed nutrient management strategies. While there are doubtless anthropogenic impacts on Lake Winnipeg’s trophic status, we conclude that the dominant event driving recent changes in the water quality of Lake Winnipeg has been extraordinary levels of precipitation in the Red River basin and the consequent disproportionate contribution of the P rich waters of the Red River to the lake. Current nutrient management strategies are brought into question. Keywords: Harmful algal blooms, Nutrients, Climate change.

STAPANIAN, M.A.¹, ADAMS, J.V.², KOCOVSKY, P.M.¹, BUR, M.T.¹, and EDWARDS, W.H.¹, ¹U.S. Geological Survey, Lake Erie Biological Station, 6100 Columbus Ave., Sandusky, OH, 44870; ²USGS, Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105.  


We examined catch per hour (CPH) in bottom trawls of young-of-year (YOY) yellow perch *Perca flavescens* and walleye *Sander vitreus* at an established monitoring site in Lake Erie during spring and autumn 1987-2005 in order to determine what factors affect seasonal abundances. For both species we rejected a null model (H₀) representing a single pattern of annual abundance for both sampling seasons and all three times of day (morning, afternoon, and night) in favor of an alternative model (Hₐ) that allowed for different patterns of annual abundance for different seasons or times of day. The year-by-season interaction was significant for both species in Hₐ, suggesting that mortality between summer and autumn varied annually. We then compared a series of 16 linear models using Akaike’s Information Criterion to see if indices of climate, water level, and predation accounted for these changes and could be used in place of the year-by-season interaction. For both species, the model that included main effects year, season, time of day, and the interaction performed best. Predicted CPH from the best model was always greatest for night sampling and least for afternoon sampling. Monitoring programs must consider effects of sampling season and time of day when assessing populations. Keywords: Monitoring, Fish.

STAPANIAN, M.A.¹, KOCOVSKY, P.M.¹, and ADAMS, J.V.², ¹U.S. Geological Survey, Lake Erie Biological Station, 6100 Columbus Ave., Sandusky, OH, 44870; ²USGS, Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105.  

Diel Shift in Young-of-year Yellow Perch: Association with Increased Oligotrophication.

Lake Erie has undergone considerable oligotrophication since the 1970s, particularly due to passage of the Clean Water Act (CWA) and the establishment of dreissenid mussels (*Dreissena* sp.). We examined bottom trawl data for young-of-year yellow perch *Perca flavescens* collected at an established site in western Lake Erie during 1961-2005 at three diel periods (morning, afternoon, and night). The time series was divided into three 15-year periods: (1) 1961-1975, representing the period before passage of CWA through 4 years after passage of CWA; (2) 1976-1991, an intermediate period; and (3) 1991-2005,
representing four years after the invasion of dreissenids through the end of the time series. Night catches were greater than daylight catches during period 3 than during the other two periods. The results are consistent with an hypothesis that night catches were associated with increasing water clarity, particularly after the establishment of dreissenid mussels. Monitoring programs of YOY yellow perch that do not include night sampling may underestimate recruitment. **Keywords:** Yellow perch, Lake Erie, Monitoring.

STEEN, P.J.\textsuperscript{1}, WILEY, M.J.\textsuperscript{2}, and SCHAEFFER, J.S.\textsuperscript{1}, \textsuperscript{1}U.S. Geological Survey, Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105; \textsuperscript{2}School of Natural Resources and Environment, University of Michigan, 170 Dana Building, Ann Arbor, MI, 48109. **Variation in the Effect of Urbanization on Michigan and Wisconsin Stream Fish: How Can Good Fish Communities Exist in Urban Areas?**

One of the primary goals in past investigations of urban stream analysis has been to understand the strength of the negative relationship between urbanization and biotic communities. However, little effort has been expended into understanding the variation that occurs around this effect; why streams with similar urban levels have fish communities of significantly different quality. In this study, I will test the hypothesis that non-urban habitat features control the variance in the relationship between fish community quality and urbanization. To do this, Michigan and Wisconsin stream reaches were classified into groups based on fish community quality and amount of urbanization in their watershed and a series of univariate tests were performed to find how natural and anthropogenic features are related to fish biotic integrity. In addition, covariance structure analysis was used to provide multivariate insight into the complex relationships that control the quality of the stream fish community. Results indicated that urban streams with a higher percentage of natural land-cover in the watershed, more point source discharges, better water quality, and proximity to non-urbanized streams were more likely to hold higher quality fish communities. **Keywords:** Urbanization, Fish management, Model testing.

STEPIEN, C.A., NEILSON, M.E., and BROWN, J.E., Lake Erie Center, University of Toledo, Toledo, OH, 43618. **New Names, Evolutionary Resolution, and Founding Sources for Exotic Great Lakes Gobies.**

Two Ponto Caspian neogobiin gobies were identified in the Lake St. Clair region of the Great Lakes in 1990: the round goby (formerly *Neogobius melanostomus*) and the tubenose goby (formerly *Proterorhinus marmoratus*). We examine their evolutionary relationships in comparison with Ponto-Caspian relatives, using nuclear and mitochondrial DNA sequences. We further test population genetic patterns for 1,000 round goby individuals across its Eurasian and North American ranges using 8 nuclear microsatellite loci. DNA evidence refutes monophyly of *Neogobius*, and we thus elevate the subgenus *Apollonia* to genus level, encompassing *A. melanostoma* (the round goby), *A. fluviatilis* (the monkey goby), and *A. caspia*. The former *P. marmoratus* comprises at least three species and we retain that name for the marine tubenose goby. The species in the Great Lakes is the newly resurrected freshwater tubenose goby *P. semilunaris*. We also identify the southern Dnieper River as the founding source population for the round goby in the Great Lakes. There is considerable population genetic variation throughout the
Great Lakes and substantial genetic diversity, supporting large numbers of propagules, several introduction events, as well as localized selection. **Keywords:** Round goby, Genetics, Invasive species.

**STEWART, K.M.**, Dept. Biological Sci., State University of New York, Buffalo, NY, 14260. **Freshwater Protected Areas (FPAs), Great Lakes and Elsewhere.**

As the world's human population expands, and ocean resources are drawn upon more heavily for food, the establishment of Marine Protected Areas (MPAs) and marine reserves is gaining increased attention. Freshwater Protected Areas (FPAs) are needed also for some of the larger lakes in North America, Africa, Asia, and elsewhere. FPAs would probably also be helpful to many rivers and innumerable smaller lakes around the world. Such “protected areas” cannot protect against all overfishing, loss of biodiversity, environmental damage from pollution, or climate change. However, protected areas do create "limited buffer areas for reseeding" and may act as banks that aid in the management of freshwater ecosystems. In all cases, it is best if decisions on the types (e.g., limited extraction, no take zones) and locations of reserves are based on good science. Getting the science right is probably less of a challenge than having to deal with the conflicting politics of multiple stakeholders. It is easy to think that people in other countries should establish FPAs on some of their selected lakes and rivers. It seems to be more difficult to bring together the science and far-sighted politics to establish FPAs on the water body near you. **Keywords:** Environmental policy, Public participation, Public education.

**STEWART, P.W.¹, REIHMAN, J.¹, LONKY, E.¹, PAGANO, J.J.², and GUMP, B.¹, ¹Department of Psychology, SUNY Oswego, Oswego, NY, 13126; ²Environmental Research Center, SUNY Oswego, Oswego, NY, 13126. Intelligence (IQ) in Children Exposed to PCBs, MeHg, and other Contaminants in the Great Lakes.**

PCBs and MeHg are among several known neurotoxic chemicals in the Great Lakes ecosystem. An important question relates to how exposure to these contaminants in children predicts cognitive development (IQ) in later childhood. Here we report new data on the relationship between exposure to PCBs and MeHg and IQ in a cohort of children in Oswego, NY. Results are discussed not only in terms of implications for public policy, but also in terms of the importance of a reasoned and considered interpretation of the data. **Keywords:** Methylmercury, PCBs, Human health.

**STEWART, T.J.¹, O‘GORMAN, R.², SPRULES, W.G.¹, and LANTRY, B.F.², ¹Department of Ecology and Evolutionary Biology, University of Toronto at Mississauga, Mississauga, ON, L5L1C6; ²United States Geological Survey, Great Lakes Science Center, Lake Ontario Biological Station, Oswego, NY, 13126. Invasive Species Disruption of the Lake Ontario Food Web Affects Alewife Diet, Production, and Consumption of Zooplankton and Mysis relicta.**

Beginning in the 1980s, a succession of non-native invertebrates colonized Lake Ontario and precipitated lake-wide disruptive changes to the food web during the 1990s. In Lake Ontario, alewife play a pivotal role in structuring the food web and transfer lower trophic level production to top predators.
Alewife diets changed after 1990 with an increase in the consumption of *Mysis relicita*, a decline in the consumption of zooplankton, a switch in cladoceran consumption from native Daphnids to the exotic cladocerans *Bythotrephes* and *Cercopagis*, and a decline in the consumption of cyclopoid copepods and small cladocerans. The increased prevalence of *Mysis* and the recently established predatory cladocerans in alewife diets means that alewife have shifted to a higher trophic position. To examine the effects of food web disruption on alewife diet and bioenergetics, we first developed population-based alewife bioenergetic models for two 5-year time periods; 1987-1991 and 2001-2005. We then compared estimates of average annual alewife biomass, alewife production, P/B ratios, total consumption, taxon-specific consumption, and associated Q/B ratios between time periods. Finally, we use error propagation techniques to determine the consequences of sampling error on variability in these estimates. 

**Keywords:** Alewife, Bioenergetics, Lake Ontario.

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Recent water level declines in Lakes Michigan and Huron have been particularly worrisome, in part because they are consistent with many global climate change scenarios. We examined water level changes over time with Dynamic Linear Models (DLMs) and Seasonal Trend Decomposition using Loess (STL). STL results highlight periodicities at several frequencies, including a relationship with sunspot activity. Interestingly, the sign of this relationship changed from positive to negative in about 1940. DLMs show a relationship with precipitation at three annual time lags, with a pseudo-r-squared of 0.89, and reveal an underlying water level decline that began in the 1970s. The DLM results provide a basis to forecast annual average water levels, given previous year precipitation, with accompanying uncertainty estimates. They may also be a useful tool to help delineate the causes of the long-term underlying water level decline. **Keywords:** Lake Michigan, Water level fluctuations, Lake Huron.

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As part of a large-scale study undertaken to understand the effects of double-crested cormorants on coastal fish communities, hydroacoustic surveys of seven different locations in Georgian Bay and the North Channel of Lake Huron were conducted from 2000-2004. Surveys were done in seven 400 km² grids and covered roughly 4.7% of the total surface area of the Georgian Bay and North Channel basins. Hydroacoustic techniques yield spatially-explicit data on the density of different size classes of fish across a variety of habitats. Using global and local measures of spatial association, we examined patterns in the spatial distribution of fish density and biomass in Georgian Bay and the North Channel at both fine- and broad-scales. Small fish (<250 mm) were generally positively autocorrelated at small spatial scales of less than ~1 km, and weakly negatively autocorrelated at greater distances. Patterns of spatial aggregation
were stronger at night than during the day for small fish, but they also varied over time, suggesting that broader-scale regional forces may be a strong influence on coastal pelagic fish in the Great Lakes. 

*Kn*owledges: Coastal ecosystems, Lake Huron, Hydroacoustics.

**STURTEVANT, R.A. and REID, D.F., NOAA National Center for Research on Aquatic Invasive Species, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105. GLANSIS: The Great Lakes Nonindigenous Aquatic Species Information System.**

The Great Lakes have a long history of introductions - intentional and unintentional - of aquatic nonindigenous species. As of 2007, at least 186 nonindigenous species have been recorded as having reproducing populations in the Great Lakes basin, *i.e.*, Lakes Superior, Michigan, Huron, St. Clair, Erie, Ontario, and their connecting channels and water bodies within their respective drainages (Mills et al. 1993, Ricciardi 2001, Ricciardi 2006, Ricciardi unpubl. data). The Great Lakes Aquatic Nuisance Species Information System (GLANSIS) functions as a Great Lakes-specific node of the USGS NAS national database of freshwater aquatic invasive species. Information entered for GLANSIS automatically appears in both databases. GLANSIS allows more direct access to the Great Lakes specific information – especially collection records. Individual fact sheets have been developed for 134 of the 186 established nonindigenous species, thereby accounting for over 70% of the known invaders in the basin. The species for which factsheets are not yet developed are all vascular plants and algae, primarily semi-aquatic species. These are listed but with only minimal information at this time. GLANSIS is available at: [http://www.glerl.noaa.gov/res/Programs/ncrais/glansis.html](http://www.glerl.noaa.gov/res/Programs/ncrais/glansis.html). 

**Keywords: Great Lakes basin, Invasive species, Outreach.**


We review vessel traffic patterns and ballast characteristics of saltwater vessels entering the Great Lakes during equal periods of time before (1978-1988, “pre-BWE”) and after (1994-2004, “post-BWE”) Ballast Water Exchange regulation. The number of ships entering as BOBs declined significantly, while the number of NOBOBs was not significantly different. The size of ships entering the Great Lakes, as reflected in gross tonnage, increased slightly during the post-BWE period; the average of annual cargo weight per transit was about 21% larger for the post-BWE period. We speculate that the total ballast amount carried into the Great Lakes potentially declined by ~76% between the pre- and post-BWE periods. The relative amount of ballast carried on NOBOB vessels was a relatively small fraction of the cumulative total ballast potentially carried into the Great Lakes during either period. We use estimated changes in ballast quantities as a simple surrogate to examine potential changes in propagule supply. The results indicate a dramatic reduction in potential propagule supply between, represented by an estimated average decrease of ~97%, equivalent to elimination of ~3.3 million t per year of unexchanged ballast water. 

**Keywords: Ballast, Invasive species, Risk assessment.**
SWINEHART, C.Y.1, JENSEN, D.A.2, MOY, P.B.3, TEPAS, K.4, KELCH, D.O.5, and DOMSKE, H.M.6,  
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Elyria, OH, 44035; 6New York Sea Grant, State University of New York at Buffalo, Buffalo, NY, 14260- 
4400. Reflections on Outreach in Uncharted Waters: How the Discovery of Zebra Mussels in the  
Great Lakes has Changed Public Outreach and Involvement in the Region.  

Zebra mussels were not the first, nor will they be the last, invasive aquatic species to become 
established in the Great Lakes. The discovery of *Dreissena polymorpha* motivated agencies,  
organizations, and institutions to form new alliances and partnerships to address the issue, to work with 
new stakeholders within the region, to use and, in some cases, develop or adapt appropriate tools/methods 
to engage affected publics, and to extend the scope of their outreach beyond the region’s geographic 
boundaries. Also involved have been the integration of environmental education principles, conservation 
philosophies, social change theory, strategic marketing and communication. This presentation will include 
experiences and evaluations, outcomes and impacts of selected outreach efforts conducted by the National 
Oceanic and Atmospheric Administration’s Sea Grant programs in the Great Lakes basin, as well as those 
of other agencies, organizations, and institutions. The authors will also offer some educated speculation 
on outreach trends for the future. Keywords: Dreissena, Outreach, Invasive species.

TAILLON, D.J. and WRIGHT, M.E., Ministry of Natural Resources, 300 Water St., Peterborough, ON, 

In the late spring and summer of 2007, thousands of common carp (*Cyprinus carpio*) died on 
eleven lakes in the Kawartha Lakes region of southern Ontario. The combination of environmental and 
biological stressors is believed to have combined and increased the stress and susceptibility of carp to 
outbreaks of *Flavobacterium columnare*. Responding to the die-off was a significant challenge to the 
Ministry of Natural Resources (MNR), Ministry of Environment, local municipalities, health units, and 
other agencies. The die-off was unexpected and occurred across a number of lakes over a three month 
time period. Primary concerns from the public related to public safety and water quality, as well as 
impacts on the aquatic ecosystem. Coordination amongst the various agencies was especially challenging 
given the multiple levels of government jurisdiction present on the landscape. Timelines associated with 
fish health testing were a source of frustration for the public, media, and partner agencies and contributed 
to the spread of inaccurate information. MNR is working with our partner agencies to develop a protocol 
associated with large-scale fish die-offs on inland waters. Lessons learned during this experience will be 
presented and are intended to provide guidance to staff in other jurisdictions. Keywords: Columnaris, 
Fish die-off, Communications.

THOMAS, S.P.1, JONES, J.2, PERSHYN, C.2, ALLEN, E.2, GREENE, M.2, MIHUC, T.B.2, 
SATCHWELL, M.F.1, and BOYER, G.L.1, 1State University of New York - College of Environmental 
Science and Forestry, 1 Forestry Dr., Syracuse, NY, 13210; 2State University of New York at Plattsburgh,
The purpose of this study was to develop and test a flow through methodology for spatially explicit mapping of Lake Champlain algal blooms. We used continuous flow through fluorometers linked to a spatial GPS signal to map chlorophyll $a$ and phycocyanin pigments to assess total algal and cyanobacterial biomass. Mapping consisted of continuous data collection using Turner Designs Algaewatch and Cyanowatch fluorometers at 1 second intervals with geo-spatial referencing at the same interval using a Garmin 17 HVS receiver. In addition to algal pigments, other parameters (primarily temperature) were also mapped using a Eureka Manta probe. Flow rates of approximately 2 L per minute were used for algal mapping. We tested a variety of flow devices and instrument set-ups. Results indicate that this method is feasible and could be applied at larger scales for first tier monitoring of algal blooms. We were able to detect bloom conditions in Lake Champlain and develop field and laboratory protocols to produce accurate bloom maps. Keywords: Spatial distribution, Harmful algal blooms, Lake Champlain.

Thiaminase has been causally-linked to thiamine deficiency and subsequently to early mortality syndrome (EMS) in Great Lakes salmonines. Thiaminase is an enzyme that degrades the essential vitamin thiamine (vitamin B1). It is produced by bacteria, yeast, algae, and possibly higher organisms, including complex plants and even fish. The catalytic activity of thiaminase (i.e., ability to degrade thiamine) has been measured in a variety of species, representing various trophic levels within the Great Lakes. However, the exact source or sources of thiaminase at the different trophic levels are not known. Potential sources of thiaminase include: 1) plankton/lower food chain; 2) visceral bacteria; or 3) de novo synthesis by the fish. An understanding of the source of thiaminase would help elucidate potential management strategies for efforts to mitigate the consequences of thiaminase on salmonine populations. The objective of this presentation is to provide an overview of our current knowledge of the presence and consequences of thiaminase in the Great Lakes ecosystem. Keywords: Food chains, Fish diseases, Vitamin B.

Toronto and Region Conservation has led the restoration and enhancement of nearshore habitats along the Toronto waterfront. Tommy Thompson Park, a man-made peninsula in east Toronto that
extends 5 km into Lake Ontario, is a case study on how a site that functions as a biological center of organization can be further enhanced through nearshore habitat restoration. Through extensive planning and consultation a strategic natural area enhancement plan for terrestrial and aquatic habitats has been developed and is being implemented. Species specific essential habitats that target a range of life stages of fish, herpetiles, shorebirds, waterbirds, and mammals and biological communities have been created and enhanced. Projects include fish spawning habitat, amphibian pools, in-water and shoreline structural habitat, waterbird habitat, coastal wetland development, and invasive species management. A range of monitoring projects has been undertaken including underwater camera surveillance, breeding surveys, radio-telemetry, vegetation mapping, electrofishing, and fish entrapment. The results show intriguing trends and document changes in the flora and fauna community. This case study documents one of the most significant changes to the nearshore community within the Toronto waterfront.

**Keywords:** Restoration, Lake Ontario, Wetlands.

TROY, C.D., Purdue University, Civil Engineering, 550 Stadium Mall Dr., West Lafayette, IN, 47907-2051, United States. **Evaluation of Low-cost Thermistor Chains for Vertical Temperature Measurement.**

We evaluate low-cost thermistor chains suitable for thermal observations in the Great Lakes. Much is known about the surface temperature variability in the Great Lakes, owing to the extensive observational and modeling efforts of the Great Lakes Environmental Research Laboratory. However, it is well known that vertical temperature structure can have a profound impact on vertical mixing of nutrients, pollutants, and biota during stratified periods. There are few reported observations of subsurface thermal structure in Lake Michigan since the pioneering observational work of Mortimer. We evaluate several different subsurface temperature measurement systems suitable for deployment in the Great Lakes. The systems include a proposed “lowest-cost” thermistor chain, with cost of approximately $500 per 10-node thermistor chain, that utilizes a novel temperature sensor relatively new to limnology. The low cost of this instrument allows for multiple, simultaneous deployments that can give important spatial information on the subsurface thermal structure. Plans are outlined for thermal measurements in southern Lake Michigan.

**Keywords:** Hydrodynamics, Monitoring, Lake Michigan.

TROY, C.D.¹, HULT, E.L.², and KOSEFF, J.R.², ¹Purdue University, School of Civil Engineering, 550 Stadium Mall Dr., West Lafayette, IN, 47907-2051; ²Stanford University, Dept. of Civil and Environmental Engineering, Environmental Fluid Mechanics Laboratory, Stanford, CA, 94305-4020. **Richardson Number Measurements in Breaking Internal Waves.**

The breaking of internal waves is known to be responsible for much of the vertical mixing observed in large, density-stratified lakes. In order to both correctly model and correctly infer the mixing associated with breaking internal waves, a thorough understanding of the instability mechanism driving these turbulent events is crucial. In this study, a primary indicator of turbulence in stratified flows, the gradient Richardson number (Ri), is examined for internal waves on the verge of instability. We use simultaneous high-resolution scalar (Planar Laser-Induced Fluorescence, PLIF) and velocity (Digital Particle Image Velocimetry, DPIV) measurement techniques to infer the gradient Richardson number of
breaking and near-breaking progressive internal waves in a laboratory channel. The results show important deviations from the oft-assumed canonical stability limit of \( \text{Ri}=1/4 \), which we attribute to the unsteadiness of the internal wave-generated shear driving the instability. This result has important implications for the diagnosis of turbulent mixing in stratified lakes. Keywords: Hydrodynamics, Instabilities and mixing, Laboratory experiments, Stratified flows.

TSIPLOVA, K.\(^1\), OBUSHENKO, N.\(^1\), REID, K.B.\(^3\), YANG, W.\(^2\), and NUDDS, T.\(^1\). \(^1\)Department of Integrative Biology, University of Guelph, Guelph, ON, N1G 2W1; \(^2\)Department of Geography, University of Guelph, Guelph, ON, N1G 2W1; \(^3\)Ontario Commercial Fisheries’ Association, 45 James St., Blenheim, ON, N0P 1A0. **Bioeconomic Risk Assessment of the Lake Erie Walleye Commercial Fishery.**

We examined the effects of alternative exploitation policies on the economic well being of the Lake Erie Canadian walleye fishermen and fish processors by developing a risk framework that incorporates biological and economic characteristics of Lake Erie commercial fishery and by evaluating how well these management policies perform within such a framework. The model consists of a discrete time and age structured Ricker equations of population dynamics. The biological model contains an error term, which reflects variation in recruitment. This biological model uses Ricker parameters that were generated using a Bayesian method and a Markov Chain Monte Carlo algorithm. The economic model consists of the profit equation. The profit is a function of the annual total catch in weight and has two components: total revenue and total cost. In order to estimate the cost function we collected financial data from the Lake Erie harvesting sector and processing sector.We evaluated the effect of various management strategies on the harvesting sector and the processing sector separately. The future time series of stochastic catch at age constitute an output. The output of the economic model is future time series of discounted stochastic profits. We used certainty equivalence and value-at-risk to rank the various walleye management options. Keywords: Economic evaluation, Fisheries, Risk assessment.

TULEN, L.A. and CORONADO, D., Citizens Environment Alliance, 1950 Ottawa St., Windsor, ON, N8Y 1R7. **The Role of the NGO in the Detroit River RAP.**

Initiated in 1987, the Detroit River RAP process has gone through numerous changes in organization, government agency interest, and agency personnel. Three non-governmental organizations have been consistently involved in the process through active membership in the Public Advisory Council. This continued involvement has provided consistency in historical knowledge, information transfer, public empowerment, and invaluable information on local issues and options for successful remediation. The involvement of these non governmental organizations has maintained political and governmental interest in a RAP program that continues its legacy as one of the most polluted rivers in the U.S. and Canada. Keywords: Detroit River, Public participation, Non-governmental organizations.
TURNER, B.A.F. 1, BOWLBY, J.N. 2, DAVIES, W.E. 1, CLARKE, D.R. 1, and GROSS, M.R. 1, 125 Harbord St., Toronto, ON, M5S 3G5; 241 Hatchery Lane, RR 4, Picton, ON, K0K 2T0. **Salmonid Cannibalism in Lake Ontario: Testing the Predator Curtain Hypothesis.**

The question of whether or not adult salmonids pose a significant predation risk to spring-running post-smolts remains an equivocal and important topic in Great Lakes fisheries management. Here we evaluate the hypothesis that poor recruitment of Lake Ontario juvenile salmonids is due to predation pressure by adults during the spring smolt migration. To test this hypothesis, we collected stomachs from adult salmonids during the spring-run, from the nearshore area surrounding Cobourg Creek, Ontario. The results presented here describe data from the first year of a three-year study. These preliminary findings do not support the hypothesis that adult salmonids pose a major predation risk to juvenile salmonids during their outmigration. However, given the limited sample size of this first year of study, it is difficult to say how representative these results are. A formalization of the predator curtain hypothesis as it applies to salmon recruitment in the Great Lakes is presented. *Keywords:  Salmon, Predation, Lake Ontario.*

TWISS, M.R. 1, WILHELM, S.W. 2, MCKAY, R.M.L. 3, BULLERJAHN, G.S. 3, DEMPSEY, J.P. 4, CARRICK, H.J. 5, and SMITH, R.E.H. 6 1Department of Biology, Clarkson University, Potsdam, NY, 13699-5805; 2Department of Microbiology, The University of Tennessee, Knoxville, TN, 37996-0845; 3Department of Biological Sciences, Bowling Green State University, Bowling Green, OH, 43403; 4Department of Civil and Environmental Engineering, Clarkson University, Potsdam, NY, 13699-5710; 5School of Forest Resources, Pennsylvania State University, University Park, PA, 16802; 6Department of Biology, University of Waterloo, Waterloo, ON, N2L 3G1. **The CACHE: A Unique Limnological Feature in Ice Covered Lake Erie.**

In February 2007, we documented discrete accumulations of elevated phytoplankton biomass, termed CACHEs (Concentrated Algal Community and Heterotrophic Ecosystems), dominated by the filamentous diatom, *Aulacoseira*. CACHEs were present throughout the central basin and approximately every 100-300 m. We hypothesize that diatom-synthesized lipid during winter is trapped in the hypolimnion by the onset of thermal stratification and causes summer hypoxia. We constructed a conceptual positive feedback model of CACHE formation that recognizes the physical and biological constraints on *Aulacoseira* growth. Since black ice is thinner than white ice due to albedo (light penetrating black ice warms water below), scalloping occurs on the bottom of the ice surface. *Aulacoseira* in the water directly below scalloped black ice will be subjected to a favorable light environment and proliferate and produce abundant lipid to maintain the advantageous light regime in the depression and overcome isopycnal forces caused by the warming of the water. The isopycnal sinking of water masses leads to convective currents that concentrate *Aulacoseira*. This hypothesis explains CACHE formation and the appearance of discrete accumulations of *Aulacoseira* biomass under the ice rather than as a widespread dispersed bloom. *Keywords:  Lake Erie, Algae, Ice.*

URBAN, N.R. 1, MCKINLEY, G.A. 2, WU, C.H. 2, ATILLA, N. 2, BENNINGTON, V. 2, and MCDONALD, C.P. 1, 1Michigan Technological University, Houghton, MI, 49931; 2University of
Wisconsin - Madison, Madison, WI. **CO2 Fluxes Across the Lake Superior Surface: Coupling of Physics, Chemistry, and Biology.**

Physics, biology, and chemistry interact in a variety of ways to regulate the flux of CO2 out of the Great Lakes. On the physics side, seasonal variations in wind speed affect the rate of gas transfer. Changes in atmospheric boundary conditions that occur on timescales of days alter both the rate of gas transfer but also the chemical gradient across the air-water interface. Physics intersects chemistry when seasonal changes in temperature change the solubility of CO2 and induce seasonal influxes and effluxes. Changes in lake mixing depth alter the fraction of the lake that actively exchanges CO2 with the atmosphere. Of course, the biological uptake of CO2 by algae in summer raises the pH and lowers the concentration of CO2 in the water thereby altering the driving force for gas transfer. Many of these processes vary in space and time. As a result, estimating an annual lake-wide flux of CO2 is problematic. This talk will demonstrate several of the phenomena discussed above as well as show a couple of approaches toward quantifying the lake-wide annual flux for Lake Superior. **Keywords: Atmosphere-lake interaction, Carbon cycle, Model testing.**

USJAK, S., and WITT, J.D.S., University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1. **Genetic Differentiation of Diporeia Populations in the Laurentian Great Lakes: Implications for Conservation and Management.**

The taxonomic status of Diporeia populations in the Laurentian Great Lakes has been the source of much confusion and uncertainty, despite their importance as energy conduits from the sediments to higher trophic levels. We conducted an analysis of mitochondrial DNA sequence variation among populations from Lakes Huron, Michigan, Ontario, and Superior to test the hypothesis that Diporeia hoyi represents a species complex in the Great Lakes. Phylogenetic analyses of the sequence data did not support the existence of two or more species. However, an analysis of molecular variance and tests of population differentiation revealed marked genetic structuring and population subdivision among the Great Lakes populations, which likely reflects historical colonization patterns and a lack of contemporary gene flow. Populations in Lake Superior represent one Evolutionary Significant Unit, while populations residing in Lakes Huron, Michigan and Ontario represent another. Given the precipitous declines of Diporeia in the Great Lakes over the past decade, these results have important implications for potential recovery and management programs. **Keywords: Taxonomic status, Mitochondrial DNA, Genetic diversity.**

UZARSKI, D.G., 1, BURTON, T.M., 2, CIBOROWSKI, J.J.H., 3, BRAZNER, J.C., 4, ALBERT, D.A., 5, OTIENO, B.S., 6, BOURGEAU-CHAVEZ, L., 7, TIMMERMANS, S.T.A., 8, and MEIXLER, M., 9, 1Department of Biology, Central Michigan University, Mount Pleasant, MI, 48859; 2Departments of Zoology and Fisheries and Wildlife, Michigan State University, East Lansing, MI, 48824; 3Department of Biological Sciences, University of Windsor, Windsor, ON, N9B 3P4; 4Inland Waters Institute, 29 Powers Dr., Herring Cove, NS, B3V 1G6; 5Michigan Natural Features Inventory, Stevens T. Mason Building, Lansing, MI, 48909-7944; 6Department of Statistics, Grand Valley State University, Allendale, MI, 49401-9403; 7Michigan Tech Research Institute, 3600 Green Ct. Suite 100, Ann Arbor, MI, 48105; 8Bird
Studies Canada, P.O. Box 160, Port Rowan, ON, N0E 1M0; Department of Natural Resources, Cornell University, 104 Rice Hall, NY, 14853. Status and Trends of Great Lakes Coastal Wetland Health: A Basin-wide Monitoring Plan.

In the 1990s, the need for indicators of the integrity of Great Lakes coastal wetlands (GLCW) was identified. In 2000, U.S. EPA-GLNPO awarded funding to the Great Lakes Commission to form the Great Lakes Coastal Wetlands Consortium (GLCWC) of over 50 organizations to design an implementable, long-term monitoring program. By 2007, the GLCWC had nearly completed development of their monitoring program, about the same time another research consortium with similar goals, the Great Lakes Environmental Indicators (GLEI) group, was also nearing completion of their project. The two consortia met in early 2007 to ensure that common methodologies, findings, and cross-validation were incorporated into the final GLCWC recommendations. The final report was prepared in 2007 and delivered to U.S. EPA-GLNPO early in 2008. The GLCWC document describes a long-term plan to monitor GLCW using a scientifically-validated experimental design, a suite of recommended plant-, invertebrate-, fish-, amphibian-, bird-, and landscape-based indicators, a thorough cost analysis, a data management system, and an implementation strategy. A summary of this plan, including findings and recommendations on bioassessment of Great Lakes coastal wetlands, will be presented. Keywords: Coastal wetlands, Biomonitoring, Ecosystem health.

VACHON, N. and FREELAND, J.R., Department of Biology, Trent University, Peterborough, ON, K9J 7B8. Invasive Phragmites in the Great Lakes Region. I. Emerging Evidence on the Relationship between Environmental Variables and Invasion Potential.

Invasive species currently present one of the most significant threats to the Great Lakes ecosystem. One particularly problematic plant is an invasive lineage of the common reed, Phragmites australis, which is reducing biodiversity and disrupting ecosystems around the Great Lakes. A multifaceted approach is needed if we are to limit the damage that is being done by Phragmites, and this should be based in part on a better understanding of which environmental factors foster its invasiveness. We are using a combination of genetics and environmental modeling to compare populations of invasive Phragmites in parts of its native (UK) and invaded (including the Great Lakes region) range to determine what combination of environmental factors (both edaphic and climatic) create ideal growth conditions. Our findings will be relevant to future management plans, some of which will be based on predictions of future climate change. Keywords: Invasive species, Habitats, Wetlands.

VANDERPLOEG, H.A.1, NALEPA, T.F.1, FAHNENSTIEL, G.L.2, POTHOVEN, S.A.2, LIEBIG, J.R.1, DYBLE, J.1, and ROBINSON, S.3, 1Great Lake Environmental Res. Lab., NOAA, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105; 2GLERL Lake Michigan Field Station, 1431 Beach St., Muskegon, MI, 49441-1098; 3CILER, Univ. of Michigan, 2205 Commonwealth, Ann Arbor, MI, 48105. Dreissenids as Nearshore and Offshore Engineers: Predicting Direct and Indirect Effects of Mussels on Pelagic Food Webs.
With invasion of dreissenids to all depth zones of the Great Lakes, we now have to consider effects of mussels across all depth regions of the lakes. We review our progress in understanding effects of dreissenids on pelagic food webs. Effects of mussel selective feeding and nutrient processing on phytoplankton composition vary across trophic gradients. The desertification of the offshore pelagic region is likely not only driven by the hypothesized nearshore P shunt, but also activities of the mussels themselves in the offshore region. Increased light and other habitat modification have led to unanticipated changes in spatial coupling and food web processes. For example, mussel filtering reducing phytoplankton along with increased water clarity have led to direct and indirect negative consequences to zooplankton through loss of food and possibly increased susceptibility to visual predation from *Bythotrephes* and *Cercopagis*. Many of the changes now seen in the Great Lake have not been anticipated from analogies of mussel impacts in other freshwater and marine systems. This stems from lack of consideration of scale, system openness, trophic status, seasonal stratification, and peculiarities of the local food webs. We have a lot to learn before we can adaptively manage the Great Lakes.

*Keywords*: Dreissena, Bythotrephes cederstroemii, Microcystis.


The Session Co-Chairs will lead an open discussion during the final speaker time slot in Session 29 to summarize the lessons learned from invited and contributed presentations during this session. Further, we hope to stimulate a discussion about future research directions and adaptive management strategies that may be necessary to deal with the realities of dreissenids and other aquatic invaders in North America over the next 20 years. **Keywords**: Exotic species, Management, Environmental effects.

VELEZ-ESPINO, L.A., KOOPS, M.A., and BALSHINE, S., 1Great Lakes Laboratory for Fisheries and Aquatic Sciences, 867 Lakeshore Road, Burlington, ON, L7R 4A6; 2McMaster University, Hamilton, ON, L8S 4K1. **Invasion Dynamics of Round Goby (Neogobius melanostomus) in Hamilton Harbour, Lake Ontario.**

Most introductions of non-native species fail to establish soon after introduction either through mortality or reproductive failure. The presence of an established population increases the probability of survival and reproductive success of new propagules by avoiding both Allee effects and demographic stochasticity. Analyzing data collected during the spread phase of the invasion, we model the probabilities of reaching critical densities for habitat saturation as a stochastic progression and backcalculate the elapsed time between arrival and establishment of round goby, *Neogobius melanostomus*, in Hamilton Harbour, Lake Ontario. Our modeling shows that (1) during the transition between arrival and establishment, propagule pressure in the form of adults can be very low and still represent a significant probability of establishment, (2) the demographic contribution of propagule pressure during the spread phase is low and its total elimination will not halt population growth and spread, (3) there is a short elapsed time between arrival and establishment, indicating the transition between arrival and
establishment can be characterized as a deterministic process underpinned by high propagule pressure and low adult mortality rates. **Keywords: Biological invasions, Round goby, Great Lakes basin.**

VENIER, M. and HITES, R.A., School of Public and Environmental Affairs, Indiana University, Bloomington, IN, 47405.  **Brominated Flame Retardant and Dioxin Concentrations on the Shores of the Great Lakes.**

Air samples were collected every 12-24 days at five near-lake sites (Eagle Harbor, MI; Chicago, IL; Sleeping Bear Dunes, MI; Cleveland, OH; and Sturgeon Point, NY) from Nov. 2003 to Dec. 2006. Samples were analyzed for polybrominated diphenyl ethers (PBDEs) and other flame retardants, such as 1,2-bis(2,4,6-tribromophenoxy)-ethane, Dechlorane Plus, and decabromo-diphenylethane. The highest mean concentrations of total PBDEs were found at the urban sites of Chicago and Cleveland (65 ± 4 and 87 ± 8 pg/m³, respectively) and the lowest at the remote site of Eagle Harbor (5.8 ± 0.4 pg/m³). BDE-47, 99, and 209 were the most abundant congeners at all sites, suggesting that the penta-BDE and deca-BDE products were the main sources of PBDEs. At the same sites, except Cleveland, polychlorinated dibenz-p-dioxins and dibenzofurans (PCDD/Fs) were measured. The highest mean concentrations were found at the Chicago site (56 ± 6 fg TEQ/m³) followed by the rural site at Sturgeon Point (28 ± 4 fg TEQ/m³) and the two remote sites at Sleeping Bear Dunes and Eagle Harbor (11 ± 1 and 4.0 ± 0.5 fg TEQ/m³, respectively). The logarithmically transformed flame retardant and dioxin concentrations showed a seasonal trend at most sites. **Keywords: Atmospheric circulation, Chemical analysis, Environmental contaminants.**

WANG, H.¹, HÖÖK, T.O.¹, COOK, H.A.², EINHOUSE, D.W.³, FIELDER, D.G.⁴, KAYLE, K.⁵, and RUDSTAM, L.G.⁶, ¹CILER, University of Michigan, NOAA/Great Lakes Environmental Research Laboratory, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105; ²Ontario Ministry of Natural Resources, Lake Erie Fisheries Station, Rural Route 2, 320 Milo Road, Wheatley, ON, N0P 2P0; ³New York State Dept. of Environmental Conservation, Lake Erie Fisheries Research Unit, 178 Point Dr., North Dunkirk, NY, 14048; ⁴Michigan Department of Natural Resources, Alpena Great Lakes Fisheries Research Station, 160 E. Fletcher, Alpena, MI, 49707; ⁵Ohio Department of Natural Resources, Division of Wildlife, Fairport Fisheries Research Station, 1190 High St., Fairport Harbor, OH, 44077; ⁶Department of Natural Resources, Cornell University Biological Field Station, 900 Shackelton Point Road, Bridgeport, NY, 13030.  **Inter-stock Variation of Maturation Schedules of Walleye in the Great Lakes Region.**

Although intra-specific variation in fish maturation schedules are induced by both plastic and adaptive processes, commonly used maturation indices (e.g., age and length at 50% maturity) do not facilitate discrimination between plastic and adaptive variation. More recently, several researchers have employed probabilistic maturation reaction norms (PMRN) to help discriminate between plastic and adaptive variation. To quantify inter-stock plastic and adaptive variation in maturation schedules and to evaluate sensitivity of maturation indices to sampling-induced biases, we quantified spatial and temporal variation of maturation schedules of walleye from Lake Erie, Saginaw Bay, and Oneida Lake using 1) age and length at 50% maturity, 2) midpoints of age-specific maturation ogives, and 3) midpoints of PMRN. Our findings suggest that while sampling month, gear, and agency effects can bias estimates of age and
length at 50% maturity, PMRN estimates are robust to gear and month effects (but sensitive to biases relating to agency effects). Furthermore, based on PMRN estimates we identified potential adaptive variation in maturation schedules among walleye stocks. Our study highlights the necessity to monitor maturation schedules using multiple maturation indices and the need to account for biases when comparing maturation schedules. **Keywords:** Life history studies, Management, Walleye.

WANG, J.\(^1\) and HU, H.\(^2\), \(^1\)NOAA Great Lake Environmental Research Lab, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105; \(^2\)CILER/UofM, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105. **Developing a Great Lakes Ice Model (GLIM) Using CIOM (Coupled Ice-Ocean Model) in Lake Erie.**

Lake ice cover is an important predictor of regional climate. Lake ice extent can modify the circulation patterns and thermal structure because: 1) wind stress drag is different in magnitude over water surface than over ice surface; 2) the albedo over ice vs. water differs, and 3) heat and moisture exchange between the atmosphere and the lake water can differ significantly (as much as an order of magnitude difference) in magnitude with and without lake ice, thus leading to striking difference in evaporation in wintertime due to wind mixing. Thus, prediction of the lake ice extent (i.e., cover) is crucial for predicting mixed layer, circulation, temperature, and lake water level, and thus for predicting primary and secondary productivity. In addition, the timing of ice melting, determined by climate variability, will determine the timing of phytoplankton and zooplankton blooms. As a first step, Lake Erie ice conditions are simulated with atmospheric forcing on synoptic and seasonal time scales (winter of 2004-2005) using the GLIM modified from Coupled Ice-Ocean Model (CIOM). The GLIM reproduces seasonal cycles of ice concentration, thickness, and velocity fields, which are validated by available satellite measurements. **Keywords:** Lake Erie, Ice, Model studies, Hydrodynamics, Climate change.

WARREN, G.J., HORVATIN, P.J., and ROCKWELL, D.C., U.S. Environmental Protection Agency, Great Lakes National Program Office, 77 W. Jackson Boulevard, Chicago, IL, 60604. **Where Have All the Daphnia Gone?**

*Daphnia* spp. have always been a small component of the Lake Superior zooplankton community. However, in the other Great Lakes, populations of *Daphnia* have been a major component of the summer zooplankton. In recent years *Daphnia* populations have declined dramatically in Lake Huron, and to a lesser extent in Lake Michigan. A number of reasons for the decline in those lakes can be postulated, including planktivory by fish and invertebrate predators and decreased productivity due to lower phosphorus levels in the lakes. Here we investigate the possibility that the decrease in phosphorus has lowered productivity and available food carbon to levels that limit *Daphnia* growth and reproduction, or that phosphorus may be the nutrient directly limiting *Daphnia*. In order to investigate this question, literature estimates of the seston carbon necessary for growth will be compared with particulate carbon data and C:P ratios derived from our monitoring program. **Keywords:** Zooplankton, Phosphorus, Predation.
WATSON, S.B.1, HUDON, C.1, and CATTANEO, A.3, 1Canadian Centre for Inland Waters, Environment Canada, Burlington, ON, L7R 4A6; 2Centre Saint-Laurent, Environment Canada, Montreal, PQ; 3Département de sciences biologiques, Université de Montréal, Montreal, PQ. Cyanobacterial Impairments in the Great Lakes-St. Lawrence River: Benthic Fingerprint of Anthropogenic Activity.

Recently, dense benthic/epiphytic cyanobacteria Lyngbya cf. wolleii and Gloeotrichia pisum have been impacting shorelines and drinking water in two areas in the Great Lakes. Both sites are located downstream from major tributaries draining agricultural regions, but differ in local flow/circulation, resuspension, and nutrient regimes. In one case, Lyngbya mats in the mouth of the Maumee River (W. Lake Erie) produce extensive shoreline and beach fouling from detached material, provoking media and public concern for potential cyanotoxins. The second impacted area is located at the confluence of the Ottawa and St. Lawrence Rivers near Montreal, where drinking water intakes are impacted by late summer taste and odor and detached algal mats. In this area both Lyngbya and Gloeotrichia develop in distinct patterns reflective of differing local P and N regimes. We describe the physico-chemical regimes of the two sites, the taxa and associated noxious metabolites, and potential socioeconomic and ecological impacts. Keywords: Cyanophyta, Harmful algal blooms, Benthos.

WATSON, S.B.1, MILLARD, S.2, BURLEY, M.2, MOLOT, L.3, and FORRESTER, L.A.3, 1Canada Centre for Inland Waters, Environment Canada, Burlington, ON, L7R 4A6; 2Canada Centre for Inland Waters, Depatment of Fisheries and Oceans, Burlington, ON, L7R 4A6; 3Faculty of Environmental Studies, York University, Toronto, ON, M3J 1P3. Cyanobacterial Impairments Following Remediation in a Eutrophic Area of Concern: Bay of Quinte, Lake Ontario.

We describe a five-year collaborative assessment of impairment by cyanobacterial blooms, toxins and taste-odor (T&O) in the Bay of Quinte, a eutrophic Area of Concern in Lake Ontario. Biweekly summer/fall samples at 4-5 sites were combined with extensive late-summer spatial surveys for physico-chemical characteristics, phytoplankton, and noxious metabolites. Our data showed that, between 2003-2007, cyanobacterial impairment was a major problem. Late summer cyanobacterial blooms were dominated by large N2-fixers (Anabaena, Aphanizomenon) and periodic outbreaks of Microcystis. Despite progress toward other delisting targets T&O remains an impairment, and is likely derived from runoff, planktonic and benthic sources in the bay. Importantly, a significant number of samples exceeded drinking water guidelines for total hepatoxic microcystin (MC). Municipal drinking water plants on the bay showed adequate removal, but high MC levels were recorded in shallow and beach areas where public exposure is not monitored. Microcystis and MC levels were well correlated each year but showed differences in regression coefficients among years. Variation among stations in average ratios of MC/chlorophyll-a and MC/Total P also suggest differences in factors modifying the response of these plankton communities to nutrients. Keywords: Bay of Quinte, Cyanophyta, Harmful algal blooms.

WEGHORST, P.L.1, WITTER, D.L.1, ORTIZ, J.D.1, and HEATH, R.T.2, 1Department of Geology, Kent State University, Kent, OH, 44242; 2Department of Biological Sciences, Kent State University, Kent, OH,

Ocean Color 3 (OC3) chlorophyll data are available from the Moderate Resolution Imaging Spectroradiometer (MODIS), but, as the name implies, the OC3 algorithm was not calibrated for inland waters. How reliable is it for Lake Erie, which is shallower, more productive, and more turbid than the ocean? OC3 and, for comparison, Cannizzaro’s shallow water algorithm were applied to the April-October MODIS data for 2002-2007. The algorithms were evaluated by linear regression of the derived chlorophyll concentrations versus 110 colocated in-situ chlorophyll measurements analyzed in the lab using standard fluorometric methods. Differences among Lake Erie’s basins and the variable quality of MODIS imagery were also considered. Neither algorithm was valid for Erie’s western basin. For the combined central and eastern basins, the Cannizzaro algorithm yielded better results; OC3 consistently under-predicted high concentrations. However, both algorithms performed significantly better when badly pixelated images were screened from the data set, suggesting that improving atmospheric correction methods may improve the accuracy of chlorophyll retrieval for Lake Erie. Overall, OC3 predicted chlorophyll concentrations well for the central and eastern basins, especially on days with clear image quality. Keywords: Remote sensing, Lake Erie, Chlorophyll.

WEGHORST, P.L.1, KLINE, W.T.2, MCMAHAN, A.C.3, and BAKERCAZAN, N.4, 1Department of Geology, Kent State University, Kent, OH, 44242; 2Department of Geography, Kent State University, Kent, OH, 44242; 3Jackson High School, 7600 Fulton Dr., Massillon, OH, 44646; 4SAMM Center, Stark County Educational Service Center, 2100 38th St., Canton, OH, 44709. Exploring Great Lakes Controversies with High School Students.

Although sound water policies are important for every citizen’s well-being, many students are unaware of where their own drinking water comes from, much less associated state and local environmental issues. We used excerpts from Peter Annin’s The Great Lakes Water Wars to provide entry-level content on the economic, political, and ecologic issues associated with diverting water from the Great Lakes basin. Students researched and debated historical case studies about proposed Great Lakes basin diversions. As a follow-up, the students identified where their own drinking water comes from, along with potential threats to their local water source. Comparing state and local water concerns helped students understand that, despite local abundance of fresh water, living in a Great Lakes state does not in any way abrogate the need for careful water resource management. Keywords: Management, Great Lakes basin, Education.

WELLINGTON, C.G., MAYER, C.M., and BOSSENBOEK, J.M., University of Toledo-Lake Erie Center, 6200 Bayshore Rd., Oregon, OH, 43618. Physical and Biological Factors Influencing Foraging Success of Age-0 Yellow Perch.

Previous studies on yellow perch foraging indicate that increased turbidity can impair foraging success, and that phytoplankton turbidity may reduce prey consumption more than sediment turbidity. Field data from western Lake Erie suggest that turbidity may co-vary with prey density. Prey
consumption usually increases with prey density, but fish foraging in highly turbid areas may have a modified functional response and therefore not forage at the expected rate. We conducted laboratory experiments to determine how larval and juvenile yellow perch respond to changes in prey density when exposed to different levels and types of turbidity. Both prey density and turbidity type had an effect on the average number of prey consumed, with greater consumption for higher prey densities and sediment rather than phytoplankton turbidity. Slopes of the consumption-prey density relationships differed among turbidity types, indicating that turbidity type does influence the functional response of yellow perch. These results suggest that phytoplankton turbidity reduces yellow perch foraging and that increasing prey density does not negate these effects. Moreover, these results reinforce the need to control factors leading to excessive phytoplankton blooms in western Lake Erie. Keywords: Recruitment, Turbidity, Yellow perch.


A long-term monitoring project to determine spatial and temporal trends of major environmental contaminants in Great Lakes herring gull eggs was established in 1974. The project has run continuously since then. Eggs were collected annually in late April-early May from 15 gull nesting sites 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 1986-2005; 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 (34.2% of cases), 2) faster in more recent years (51.3%), 3) slower in more recent years (3.3%), or 4) showed no significant trend (11.3%). 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. 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. Two other compounds were greatest in Lake Ontario and one in Lake Superior Keywords: Organochlorine compounds, Monitoring, Avian ecology.

WHITE, M.S., XENOPOULOS, M.A., and METCALFE, R.A., Watershed Ecosystems Graduate Program, Trent University, Peterborough, ON, K9J 7B8; 2Department of Biology, Trent University, Peterborough, ON, K9J 7B8; 3Renewable Energy Section, Ministry of Natural Resources, Peterborough, ON, K9J 7B8. Characterizing Water Level Fluctuations in Large Lakes of Ontario.

Very few studies have statistically characterized water level fluctuations (WLF) in lakes. Here we present long-term WLF data (~20 yrs, sampled on weekly intervals during the ice-free season) for sixteen small (10-500 ha) lakes in the Laurentian Great Lakes region and short-term WLF data (1yr, sampled hourly all year) for twenty large (>1,000 ha) lakes in Northern Ontario. The long-term data reveal that
mean yearly amplitude in water level does not exceed 1.27 m (\(\bar{x} = 0.26 \pm 0.15\) m) and yearly average water levels do not deviate greater than 0.75 m (\(\bar{x} = 0.10 \pm 0.11\) m) from the long-term mean. Linear and waveform regression analyses revealed a significant (p £ 0.05) decreasing trend in water levels and a ten year oscillation in WLF. Analysis of the high resolution data for large lakes revealed regional groupings and yearly amplitudes between 1 and 2 meters. Further, wavelet analysis demonstrated consistent patterns among hydrographs. We will compare our results to WLF data from the Great Lakes. Record low water levels are now being recorded in several lakes across the globe (e.g., Lake Superior) and a better understanding of WLF is critical to assess loss of ecosystem services. Keywords: Lake model, Water level fluctuations, Great Lakes basin.

WILHELM, S.W. 1, MCKAY, R.M.L. 2, TWISS, M.R. 3, BULLERJAHN, G.S. 2, BOURBONNIERE, R.A. 4, CARRICK, H.J. 2, OSTROM, N.E. 6, AL-RSHAIDAT, M.M.D. 2, LECLEIR, G.R. 1, STERNER, R.W. 7, MARVIN, C.J.H. 4, and SMITH, R.E.H. 8, 1Department of Microbiology, The University of Tennessee, Knoxville, TN, 37996; 2Department of Biological Sciences, Bowling Green State University, Bowling Green, OH, 13210; 3Department of Biology, Clarkson University, Potsdam, NY, 13699; 4Environment Canada, National Water Research Institute, Burlington, ON, L7R 4A6; 5School of Forest Resources, The Pennsylvania State University, University Park, PA, 16802; 6Department of Zoology, Michigan State University, East Lansing, MI, 48824; 7Department of Ecology, Evolution and Behavior, The University of Minnesota, St. Paul, MN, 55108; 8University of Waterloo, Department of Biology, Waterloo, ON, N2L 3G1. Winter Assessment of Microbial Biomass and Metabolism (WAMBAM): A First Look at Winter Pelagic Biology in Lake Erie and the Implications of Climate Change.

Most of what we know about the biology of the Laurentian Great Lakes is based on studies in the early spring to late summer period. In contrast, few studies have been carried out in other seasons, particularly winter. In response to this need the MELEE consortium voyaged the length of Lake Erie in February 2007 on an icebreaker during a period in which the lake was 90% ice-covered. The research team sought to answer the question: “What microbes are in the lake in the dead of winter and what are they doing?” A remarkable discovery was the documentation of high phytoplankton biomass dominated by the filamentous centric diatom, Aulacoseira spp. Large accumulations of Aulacoseira were visibly associated with ice cover. Moreover, phytoplankton biomass in the water column in ice-free regions persisted at levels far exceeding (up to 10-fold) chl-a levels normally found during spring and summer. The results of our survey, combining classical and state-of-the-art techniques will be presented to demonstrate the importance of winter production in the overall scheme of total lake productivity. We will also present these results in light of the potential for climate change to affect ice cover, and to provide insight on how this biomass influences seasonal hypoxia (“dead zone formation”) late in the summer months. Keywords: Lake Erie, Biogeochemistry, Habitats, Hypoxia.

WILSON, H.F. 1 and XENOPOULOS, M.A. 2, 1Watershed Ecosystems Graduate Program, Trent University, Peterborough, ON, K9J 7B8; 2Department of Biology, Trent University, Peterborough, ON, K9J 7B8. Landscape Determinants of DOC Concentration and Character in Streams of the Laurentian Great Lakes Basin.
Dissolved organic carbon (DOC) plays an important role in freshwater by influencing spectral characteristics, secondary production, nitrogen dynamics, and the mobility of contaminants. We examined the influence of watershed land use and morphology on dissolved organic carbon (DOC) concentration and character in thirty-six south-central Ontario streams dominated by varying agricultural land use intensities. Agricultural land uses were not significantly correlated to stream DOC concentrations. The proportion of a stream’s watershed with poorly drained soil better predicts concentrations than any other landscape characteristic \( r^2 \) up to 0.67, including the proportion of the watershed as wetland. DOC character is, however, strongly related to land use, with DOC exported from more agricultural catchments being more autochthonous in character. Monoculture within the watershed is highly correlated with DOC fluorescence ratios \( r^2 = 0.83 \). For both DOC concentration and character, we show that the influence of landscape changes seasonally based on regional moisture conditions. Relationships of DOC with landscape characteristics become less predictable during periods of wetness or dryness.

**Keywords:** Dissolved organic matter, Land use, Seasonality.

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**Trends in the Water Chemistry of Lake Simcoe over Three Decades and Changes in Phytoplankton Community Composition.**

There is concern over the impact of rapid urbanization in the Lake Simcoe watershed on the nutrient status of the lake. Lake Simcoe is the largest lake in southern Ontario after the Great Lakes and is located close to half the population of Ontario. Recruitment failure of the lake’s native cold-water fishery has primarily been attributed to a three-fold increase in phosphorus loading from pre-settlement rates and consequent oxygen depletion in the hypolimnion and spawning shoal degradation. This led to the formation of a multi-agency partnership working toward reductions in phosphorus loads from the watershed. The whole lake volume-weighted spring total phosphorus concentration decreased significantly from 1980 to 2007. There was a significant increase in minimum volume weighted hypolimnetic dissolved oxygen concentration from June to September over the same period, which now fluctuates around 5 mg/L. Significant increases in water clarity have been observed at all lake stations coinciding with the establishment of dreissenid mussels. However, phytoplankton biovolume only decreased significantly at 3 stations in Cooks Bay at the south end of the lake. We will assess changes in phytoplankton community composition from 1980 to 2007 in relation to phosphorus loading, exotic species invasions, and trends in water chemistry.

**Keywords:** Lake Simcoe, Water quality, Phytoplankton.

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**Developing Water Conservation and Efficiency Objectives for the Great Lakes Basin.**

WOJNAROWSKI, L.A. and JONAS, J., 135 E. Wacker Drive Suite 1850, Chicago, IL, 60601; 101 S. Webster, PO Box 7921, Madison, WI, 53707-7921.**
The Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement was signed by the Great Lakes Governors and Premiers on December 13, 2005. In the Agreement, the Governors and Premiers committed to develop regional water conservation and efficiency goals and objectives which would then be used to inform the development of state and provincial water conservation and efficiency goals and objectives. These goals and objectives will later shape state and provincial water conservation programs. In drafting the proposed regional objectives, a Conservation Committee of state and provincial staff sought the input of an Advisory Panel of regional stakeholders and consulted with Great Lakes Tribes and First Nations. Public comment was invited, and revisions to the draft objectives were made following a review of the public comments. On December 4, 2007, the Regional Body adopted regional water conservation and efficiency goals and objectives. The Initiative will now assist the Great Lakes states and provinces in working together as they develop more specific conservation and efficiency goals, objectives, and ultimately programs in their respective jurisdictions. The Initiative will also serve as a forum for the involvement of Tribes and First Nations, regional stakeholders, and others.

Keywords: Planning, Conservation, Policy making.

WOOLNOUGH, D.A., FROST, P.C., and XENOPoulos, M.A., Biology Department, Trent University, 1600 West Bank Dr., Peterborough, ON, K9J 7B8. Transitions from Agricultural to Urban Ecosystems: A Nutrient Approach.

From the mid-18th century transition of natural wetlands to agriculture to the current shift of agriculture to urban development, we know many aquatic ecosystems have experienced intense physical and chemical stress. We investigated the chemical stress during transition from agriculture to urban land use in streams in an area undergoing rapid urbanization over the last 5 years. Stream water quality data (>50 parameters; nutrient and metals) were collected at sites upstream of development located in agricultural areas and sites located within and downstream of development. Monthly sampling in 2007 show urban sites to have less variability and to be more typical of native ecosystems (i.e., natural wetlands) than the upstream agricultural sites. For example, total phosphorus (TP) levels peaked in one agricultural site in October at 1371 μg/L whereas the average TP for downstream urban sites during the same sampling event was 172 μg/L. We will present nutrient data results and our speculation on the possible drivers of these relationships observed across the transition from agricultural to urban land use.

From the mid-18th century transition of natural wetlands to agriculture to the current shift of agriculture to urban development, we know many aquatic ecosystems have experienced intense physical and chemical stress. Keywords: Urbanization, Ontario, Nutrients, Agricultural, Chemical analysis, Transition.

WRIGHT, M.E.1 and LUMSDEN, J.S.2, 1Fish Culture Section, OMNR, 300 Water St., 5th Floor, North Tower, Peterborough, ON, K9J 8M5; 2University of Guelph, 50 Stone Road East., Guelph, ON, N1G 2W1. Surveillance for Viral Hemorrhagic Septicemia Virus (VHS) in Wild Fish Populations in Ontario.

The Great Lakes strain of viral hemorrhagic septicemia virus (VHS) was identified for the first time in freshwater drum collected from the Bay of Quinte, Lake Ontario in 2005. Although this was the
first detection of VHSV in the Great Lakes basin, archived samples collected two years earlier from Lake St. Clair also had the virus indicating that this strain of the virus has been in Great Lakes fish since at least 2003. The VHS virus may be spread through fish-to-fish contact in water and by inanimate objects such as boats and fishing gear. Therefore, it is possible that the VHS virus has already spread beyond the Great Lakes and is present in Ontario inland waterbodies. In 2007, the Ontario Ministry of Natural Resources took action to slow the spread of VHS and developed a surveillance program to test wild fish populations for VHS. Fish were collected from six sites in spring and six sites in fall. The selection of sites, test results, and implications to fish populations and fisheries management will be presented. Keywords: Fish diseases, Monitoring, Ontario Ministry of Natural Resources.


Estimate of erosion potential is critical for contaminated sediment assessment. Better characterizing bottom sediment substrates and monitoring flow and turbulent motions are important to understand the complex interactions between sediment properties and near-bed hydrodynamic processes. This study would discuss (i) the discrepancy of critical shear stress and erosion rates obtained by sediment cores and in-situ measurements; (ii) the sub-bottom sediment layer structures mapped by an acoustic sub-bottom profiler; (iii) near-sediment concentration, flow and turbulence obtained by a bottom erosion and deposition system (BEDS) that consists of laser in-situ scattering and transmissometry, acoustic Doppler current profiler and acoustic Doppler velocimeter; and (iv) application of a hydrodynamic-sediment model to assess the erosion potential under extreme flooding conditions and changing climate scenarios. Keywords: Hydrodynamics, Sediment resuspension, Water level fluctuations.


Cyanobacterial blooms have become a relatively common occurrence in Lake Erie. Early detection of these blooms would be advantageous to reduce some negative impacts associated with these blooms. We will demonstrate a proposed operational forecast system utilizing remotely sensed data and simple modeling techniques to locate and forecast blooms. We have developed remotely sensed data products that have proven to be successful for detection of larger (>20 km²) cyanobacterial blooms. Trajectories are created using the General NOAA Operational Modeling Environment ( GNOME). The inputs are the analyzed bloom field and currents from the Great Lakes Coastal Forecasting System. GNOME then proceeds to predict where the bloom is likely to propagate. Results from recent experiments will be shown. The impact of uncertainty in both the bloom field and the currents is also assessed as part of the analysis. Keywords: Lake Erie, Algae, Remote sensing.
XIA, X.¹, CRIMMINS, B.¹, HOPKE, P.¹, PAGANO, J.J.², MILLIGAN, M.S.³, and HOLSEN, T.³,
¹Clarkson University, Potsdam, NY; ²SUNY Oswego, Oswego, NY; ³SUNY Fredonia, Fredonia, NY.
Great Lakes Fish Monitoring Program: Toxaphene Results Using GC-MS/MS.

The Great Lakes Fish Monitoring Program (GLFMP) began in 1980 as a cooperative effort to
track the trends of selected organic contaminants in the Great Lakes ecosystem. Currently, two facets of
this program assess the fishery contaminant burden (Open Lakes Trend Monitoring Program) and human
exposure (Game Fish Fillet Monitoring Program) using whole fish composites and game fish fillets,
respectively. In this paper toxaphene concentrations were measured in open water whole fish and fillet
samples using a gas chromatograph (GC) equipped with an ion trap mass spectrometer. Using MS/MS
allowed for the unambiguous identification of toxaphene congeners by quantifying daughter ion 89 m/z
from parent 125 m/z ion fragment. Compared to the conventional negative chemical ionization technique,
there is no need for the problematic subtraction of co-contaminants with similar ionization fragments
(chlordanes). Using this relatively new technique, Parlars 26, 38, 40, 41, 44, 50, and 62 and total
toxaphene were quantified in Great Lakes fish collected in 2004 and 2005. Results from 2004 and 2005
open water samples will be presented in addition to a direct comparison between this relatively new
GCMS/MS technique and the conventional negative chemical ionization methodology. Keywords: Toxic
substances, Environmental contaminants, Fish.

YADAV, B.V. and ATKINSON, J.F., Great Lakes Program, University at Buffalo, Buffalo, NY, 14260.
Circulation and Mixing in Lake Champlain.

A study is conducted to evaluate circulation and mixing characteristics of Lake Champlain, to
support analysis of the evolution and transport of algae blooms in the lake. Previous data using both
Eulerian and LaGrangian measurements indicate that details of the circulation pattern are strongly
dependent on local wind stress and that complicated vertical shears are often seen. Hydrodynamic
modeling is difficult in this lake due to its many islands, complex bathymetry and shoreline. As an
alternative, a non-steady mass balance model for chloride is developed to evaluate dispersive mixing
between main segments of the lake. It is shown that dispersive mixing often dominates advective
transport, likely due to processes such as the internal seiche, and that the non-steady results are
significantly different from results of a previous steady-state model based on annual average conditions.
General flows and dispersive transports are summarized for average conditions in summer months.
Keywords: Water quality, Computer models, Water currents.

YANTSIS, S.N. and CHOW-FRASER, P., McMaster University, 1280 Main St. W., Hamilton, ON, L8S
4K1. Understanding Zooplankton Distribution and Plant Associations in Georgian Bay.

Interactions among trophic levels in the lower food web of Great Lakes coastal wetlands have yet
to be fully understood. Lower trophic levels are of particular interest since zooplankton are thought to
respond more quickly to changes in environmental quality than larger organisms such as fish and
macrophytes. In 2002, the Wetland Zooplankton Index (WZI) was developed with a dataset from 70
wetlands across the Laurentian Great Lakes basin. Due to the under-representation of upper lakes sites,
the WZI has proven ineffective for predicting quality of pristine wetlands found in Georgian Bay. We investigate the reasons why the WZI does not apply to higher quality sites, by determining factors other than water quality variables that may affect zooplankton distribution. We explored zooplankton distribution using canonical correspondence analysis (environmental variables) and co-correspondence analysis (community variables) and have found that the plant community is a better predictor than water quality parameters. Though specific relationships are yet to be determined, it is evident that wetland macrophytes have a significant impact on the community structure of zooplankton in coastal wetlands and for pristine wetlands, it is a better predictor of zooplankton presence than is water quality.

Keywords: Georgian Bay, Zooplankton, Coastal wetlands.

YERUBANDI, R.R.1, ZHAO, J.1, and MARVIN, C.H.1, 1Environment Canada, National Water Research Institute, Burlington, ON, L7R4A6; 2Environment Canada, Burlington, ON. Application of a Numerical Model for Circulation and Thermal Structure in Hamilton Harbour.

The restoration of Hamilton Harbour from an environmental standpoint is a current concern for the agencies involved with the remediation efforts in the harbor. Estimates of circulation and mixing are needed to assess the fate and transport of water quality constituents in the harbor. A three-dimensional hydrodynamic modeling system (ELCOM) is used to study the circulation and thermal structure in the harbor. The model results were compared with profiles of temperature at several moorings and currents and water levels in the harbor. The model showed considerable skill in reproducing the thermal structure, surface currents and water levels. Mean summer circulation in the harbor showed two counter-rotating gyres occupying the harbor. The model-produced harbor-lake exchange characteristics are in agreement with previous studies. Simulations using passive tracers qualitatively agreed with a sterol concentration distribution at a sewage treatment plant outfall. The level of skill shown in these simulations suggests that the model is capable of describing flow and transport of material required for detailed water quality simulations. Keywords: Computer models, Hydrodynamics, Water currents.

YOUNG, D., WILKINS, G., and MEEK, S., Toronto and Region Conservation, 5 Shoreham Dr., Toronto, ON, M3N 1S4, Canada. Turning Recommendations into Actions - The Humber River Watershed Plan.

Effective implementation of watershed plans requires clear actions with timelines and responsibilities, clear lines of accountability, and the support of partners, politicians, and stakeholders. A new generation of watershed plans has been developed by the Toronto and Region Conservation Authority for some of the rapidly urbanizing watersheds of the Greater Toronto Area that drain to the north shore of Lake Ontario, a Great Lakes Area of Concern. As part of these watershed planning studies, efforts have focused on providing policy makers, program managers, and stewardship groups with improved guidance regarding strategic initiatives needed to maintain or improve watershed health. Guidance provided by the Humber River Watershed Plan illustrates some of the new directions being put forward in these watershed plans. Based on findings from an interdisciplinary modeling study of current and potential future conditions and drawing on outputs from region-wide groundwater and natural heritage studies, specific portions of the watershed have been identified where new policies are needed.
and where priority restoration initiatives should be undertaken. **Keywords:** Lake Ontario, Planning, Watersheds.

YU, H.¹, JIAO, Y.¹, and REID, K.B.², ¹Virginia Tech, 101 Cheatham Hall, Blacksburg, VA, 24060; ²Ontario Commercial Fisheries Association, 45 James St., Blenheim, ON, N0P 1A0. **Comparing Two Methods for Estimating Relative Abundance Index of Yellow Perch (**Perca flavescens**)) by Standardization and Interpolation from Fishery-independent Survey Data in Lake Erie.**

There are various statistical models to estimate fish relative abundance index, in which a generalized linear model (GLM) is the most often used approach. However, spatial autocorrelation often exists in fisheries survey data, which will violate the assumption that the observed catch rate data are independent when we estimate relative abundance index using them. In addition, selecting explanatory variables is always a difficulty when using GLMs. In order to avoid these problems, spatial interpolation is assumed to be a new method to replace GLMs when survey intensity is high enough and spatial coverage is large enough. In this study, there is significant spatial autocorrelation in the survey catch data, so the relative abundance index of yellow perch (*Perca flavescens*) from fishery-independent survey data in Lake Erie was estimated by both GLM standardization and spatial interpolation approaches during 1990-2003. After investigating the correlations of predicted values from standardization and interpolation with the population abundance estimated through catch-at-age model, we found that the interpolation model was suitable as an alternative way to estimate relative abundance index with spatial autocorrelation for yellow perch in Lake Erie. **Keywords:** Model studies, Yellow perch, Lake Erie.

YULE, D.L.¹, GORMAN, O.T.¹, ADAMS, J.V.¹, BUNNELL, D.¹, EBENER, M.P.², and KELLY, J.R.³, ¹Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105; ²Chippewa Ottawa Resource Authority, 179 W. 3 Mile Road, Sault Ste. Marie, MI, 49783; ³U.S. Environmental Protection Agency, 6201 Congdon Blvd., Duluth, MN, 55804. **Development of a New Lake-wide Multiple Gear Survey Design to Assess Status and Trends of the Lake Superior Fish Community.**

The U.S. Geological Survey Great Lakes Science Center has developed a plan to implement revision of its annual fish community survey of Lake Superior. The primary objective of the revision is improvement of the sampling design to be more representative of the Lake Superior fish community and thereby provide more accurate information for natural resource management partners. The secondary objective will be integration of lower trophic assessment (zooplankton, macroinvertebrates) into the survey. A team of inter-agency experts has been formed to 1) explore how to best stratify the lake to achieve a representative sampling design, and 2) use recently collected data to determine the level of sampling effort required to achieve precise estimates of density and biomass of important species. Following completion of a new draft survey design, it will be subjected to peer review by outside experts. In our presentation we will provide an overview of our plan to develop a new survey design, share preliminary findings of the design team, and solicit comments from the audience to provide additional input into the plan development. **Keywords:** Acoustics, Trophic level, Monitoring.
YURISTA, P.M., KELLY, J.R., and MILLER, S.E., U.S. EPA (Mid Continent Ecology Division), 6201 Congdon Blvd., Duluth, MN, 55804. **Lake Superior Zooplankton LOPC Biomass Prediction Compares Well with a Probability-based Net Survey.**

We conducted a probability-based sampling of Lake Superior in 2006 and compared the zooplankton biomass estimate with laser optical plankton counter (LOPC) predictions. The net survey consisted of 52 sites stratified across three depth zones (0-30, 30-150, >150 m). The LOPC tow surveys were extensive and spatially covered much of Lake Superior (>1,300 km). The LOPC data were field calibrated to Lake Superior zooplankton net samples and collected across the years of 2004 to 2006. The volume-weighted lake wide zooplankton biomass determined by traditional net tows to 100 m was found to be 20.1 mg dry-weight m⁻³. The sample site estimates varied by depth zones within the lake, where nearshore (0-30 m) estimates were highest and highly variable. With field calibration sites removed, the net estimate 19.9 mg dry-weight m⁻³ and LOPC lake wide prediction of 16.7 mg dry-weight m⁻³ agreed well. Variability for LOPC data was highest in thermocline regions and regions less than 100 m. Consistency in lake-wide estimates suggests that rapid and spatially diverse LOPC data provides a comparable assessment tool to traditional nets for collecting zooplankton biomass data. This abstract does not necessarily reflect EPA policy. **Keywords: Assessments, Lake Superior, Zooplankton.**

ZHANG, J.¹, CIBOROWSKI, J.J.H.¹, DROUILLARD, K.G.², and HAFFNER, G.D.², ¹Dept. of Biological Sciences, University of Windsor, Windsor, ON, N9B 3P4; ²Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, N9B 3P4. **Zoobenthic Community Indicators of Sediment Contamination in the L. Huron- L. Erie Corridor: Application of the Reference-degraded Continuum Multivariate Approach.**

We investigated macroinvertebrate community composition and sediment contamination using data collected from 311 sites in 1991, 1998, and 2004. Multivariate analysis was used to develop Zoobenthic Condition Indices (ZCI) of sediment quality. Sites representing least and most contaminated 20th percentiles of a contaminant gradient were designated “reference” and “degraded,” respectively. Cluster analyses identified 2 groups of reference sites (soft substrate; hard substrate), each with characteristic relative abundances of zoobenthos and associated habitat features. A ZCI was derived for each group, and a ZCI score assigned to each site, summarizing its biological quality given local habitat attributes. For each group, ZCI score declined with increasing sediment contamination. Hard substrate reference areas were dominated by Chironomidae, Hydropsychidae, and *Dreissena* mussels; soft-substrate reference areas supported Chironomidae and (occasionally) *Hexagenia*. Degraded sites were dominated by Oligochaeta regardless of substrate texture. For both indices, ZCI threshold scores could be identified describing reference/nonreference biological boundaries and degraded/nondegraded boundaries. Detroit R. sediment quality improved significantly between 1991 and 2004 but improvements in zoobenthic community condition were not statistically significant. **Keywords: Bioindicators, Zoobenthos, Detroit River.**

ZHANG, X.¹, DIAMOND, M.L.¹, HARRAD, S.², and IBARRA, C.², ¹Department of Geography, University of Toronto, Toronto, ON, M5S 3G3; ²School of Geography, Earth, and Environmental
Sciences, University of Birmingham, Birmingham. **Estimation PBDEs' Emission from Sources in the Indoor Environment.**

Brominated flame retardants such as polybrominated biphenyl ethers (PBDEs) have been widely detected various media (e.g., sediment and biota) in the Great Lakes. Studies show that major sources of PBDEs in the Great Lakes originate from indoor environments within urban areas, where large amounts of PBDE-containing consumer products such as computers and polyurethane foam (PUF) are used. To better understand and mitigate contaminants in the Great Lakes, it is important to trace chemicals to their source. This study focuses on the sources and fate of PBDEs in the indoor environment, where PBDEs are first released. Air and dust samples were analyzed from 20 indoor environments within the Greater Toronto Area to better understand the indoor PBDE levels. A multimedia indoor environmental model was developed to illustrate the emission and fate of PBDEs indoors. Factors affecting PBDE levels and transport from indoors to outdoors were evaluated with the model. **Keywords: PBDEs, Source, Emission.**

ZHAO, Y.M.¹, JONES, M.L.², SHUTER, B.J.⁴, and ROSEMAN, E.F.⁴, ¹Ontario Ministry of Natural Resources, Lake Erie Fishery Station, 320 Milo Road, Wheatley, ON, N0P 2P0; ²Department of Fisheries and Wildlife, Michigan State University, East Lansing, MI, 48824; ³Department of Ecology and Evolutionary Biology, University of Toronto, Harkness Laboratory of Fisheries Research, OMNR, 25 Harbord St., Toronto, ON, M5S 3G5; ⁴USGS Great Lake Science Center, 1451 Green Road, Ann Arbor, MI, 48105. **A Biophysical Model of Lake Erie Walleye Explains Inter-annual Variations in Recruitment.**

We used a 3-D coupled hydrodynamic-ecological model (ELCOM_CAEDYM) to investigate how lake currents during the spawning-nursery period can affect walleye recruitment in western Lake Erie. The hydrodynamic model was driven by observed meteorological observations. Four years (1995, 96, 98 and 99) were selected for the study. Two years (i.e., 1996 and 99) exhibited high recruitment values and the other two years (i.e., 1995 and 1998) exhibited low recruitment values. During the two low recruitment years, the model predicted that (i) the walleye spawning ground experienced destructive bottom currents capable of dislodging eggs from suitable habitats (reefs) and moving them to unsuitable habitats (i.e., muddy bottom), and (ii) that the majority of newly hatched larvae were transported away from known suitable nursery grounds. Conversely, during the two high recruitment years, predicted bottom currents at the spawning grounds during the early part of the spawning season were relatively weak and the predicted movement of newly hatched larvae was toward suitable nursery grounds. Thus, a temporal and spatial match between walleye first feeding larvae and their food resources was predicted for the two high recruitment years and a mismatch was predicted for the two low recruitment years. **Keywords: Walleye, Recruitment, Hydrodynamic model.**

ZHU, B.¹, HALFMAN, J.D.², MAYER, C.M.³, RUDSTAM, L.G.⁴, and MILLS, E.L.⁴, ¹Finger Lakes Institute, 601 S. Main St., Geneva, NY, 14456; ²Hobart and William Smith Colleges, 112 Lansing Hall, Geneva, NY, 14456; ³University of Toledo, Lake Erie Center, 6200 Bayshore Road, Oregon, OH, 43618; ⁴Cornell University Biological Field Station, 900 Shackelton Point Road, Bridgeport, NY, 13030. **Local and Lake-wide Effects of Dreissenids on Nitrogen and Phosphorus Cycling in Lakes.**
Dreissenids can affect nutrient cycling at different spatial scales in lakes through filtration of seston, resuspension of feces and pseudofeces, excretion, and tissue emaciation. We conducted a mesocosm experiment to simulate local effects of dreissenids on nitrogen (N) and phosphorus (P) and used long-term data in Oneida Lake and the Finger Lakes to investigate the lake-wide effects. Results from the experiment revealed soluble reactive phosphorus (SRP) in water was significantly higher when dreissenids were present (14.3±1.8 vs. 10.7±1.5 µg/L) but total phosphorus (TP) and N:P ratios remained unaffected. However, total nitrogen (TN) was significantly higher with dreissenids (0.64±0.03 vs. 0.57±0.05 mg/L) due to a marked increase in nitrate (+31.3%) whereas ammonia was not affected. In addition, there was a significant increase of nitrate in sediments when dreissenids were present (6.4±1.7 vs. 2.0±1.2 µg/g sediment). These results suggest dreissenids can locally increase nitrate, TN, and SRP. Conversely, data from Oneida Lake and the Finger Lakes revealed minimal changes in TP, SRP, and nitrate, except perhaps Seneca Lake. We conclude that dreissenids may have strong local effects but minor lake-wide effects on N and P cycling in lakes, a finding in support of the nearshore shunt hypothesis. Keywords: Dreissena, Oneida Lake, Exotic species, Finger Lakes, Phosphorus, Nitrogen.

ZHU, X.1, ZHAO, Y.M.1, MATHERS, A.2, and JOHNSON, T.B.2, 1Lake Erie Fisheries Station, Ontario Ministry of Natural Resources, Wheatley, ON, N0P 2P0; 2Glenora Fisheries Station, Ontario Ministry of Natural Resources, Picton, ON, K0K 2T0. Reconstruction of Biomass Trends of American Eel Anguilla rostrata Population in Lake Ontario and Upper St. Lawrence River, 1959-2004.

The American eel Anguilla rostrata is a catadromous panmictic species that once yielded up to 250 tons of commercial harvest in Lake Ontario and St. Lawrence River in 1978. Since 1993, eel harvests have declined precipitously in all areas above the Moses-Saunders Power Dam due to a significant decline in recruitment of eel and continued high exploitation. We developed a surplus production model to evaluate the contribution of fishing to the eel decline that used maximum likelihood strategies based on commercial harvests and independent surveys in eastern Lake Ontario during 1959-2005. Over that time period, fishing effort increased 16-fold, resulting in a 9-fold increase in fishing mortality and an 89% decrease in lake-wide population biomass. Research surveys after 1985 indicated that continuous declines in both carrying capacity and intrinsic growth rate were significantly correlated with yellow eel abundance and population turnover rate through time. We will discuss the development of biological reference points for the restoration of American eel population in the Lake Ontario ecosystem. Keywords: Fish populations, Lake Ontario, American eel.


The purpose of this study is to monitor water quality using both MODIS and WASP-Lite data for improving beach closure predictions at Ontario Beach, Rochester, NY. We explored the potential for using MODIS 250-m data for TSS concentration monitoring. The study area is the Rochester Embayment and nearby waters. Field surveys on Sept. 18, 2007 showed, after using a single scattering atmospheric correction, the calibrated RRS at 645 nm closely correlated with RRS measured with a Ocean Optics
spectrometer: \( RRS_{OP} = 1.0952 RRS_{MODIS}, \) \( R^2 = 0.85 \). The relationship between MODIS \( RRS_{645} \) and TSS concentration is also closely correlated: \( TSS = 0.1244 \exp(589.93 RRS_{645}), \) \( R^2 = 0.86 \). Further, the shape of the relationship is comparable with modeled results using the HYDROLIGHT. The RIT WASP-Lite multispectral sensor underflew MODIS, providing additional data with higher spatial and spectral resolution. Because it is a high spatial resolution airborne sensor, pre-processing including image registration, radiance calibration, glint removal, and atmospheric correction were required. A modeling system based on DDDAS concepts can assimilate the results from both MODIS and WASP-Lite to improve the prediction of TSS distribution near the beach. These results can be used to help in the assessment of conditions related to beach closure decisions. Keywords: Lake Ontario, Remote sensing, Sediment transport.


A portion of the study investigating PPCPs in fish tissue from wastewater effluent dominated streams focuses on documenting the concentrations of PPCPs, hormones, and APEs in the effluent of the Northside Water Reclamation Plant and 4 km downstream of the outfall in the North Shore Channel of the Chicago River. This ancillary effort was also a collaborative partnership between several Federal Agencies, Universities, and City Departments. Objectives included the (1) exploration of diurnal and seasonal variations in concentrations; (2) the correlation of treatment plant parameters on PPCP concentrations in effluent; and (3) the potential impact of stream attenuation on fish exposure. Preliminary results suggest that APEs concentrations inversely correlate with temperature, however nonylphenol concentrations do not exceed the toxicity based criteria recommendations designed to protect aquatic life in fresh water. Additional results to be shared further discuss diurnal and seasonal variability of concentrations; the effect of temperature, flow, and ammonia on concentrations in effluent; and the persistence of some PPCPs downstream. An attempt will also be made to estimate BCFs for some compounds with available fish tissue data. Keywords: PPCPs, Wastewater, APEs.
## Author Index

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