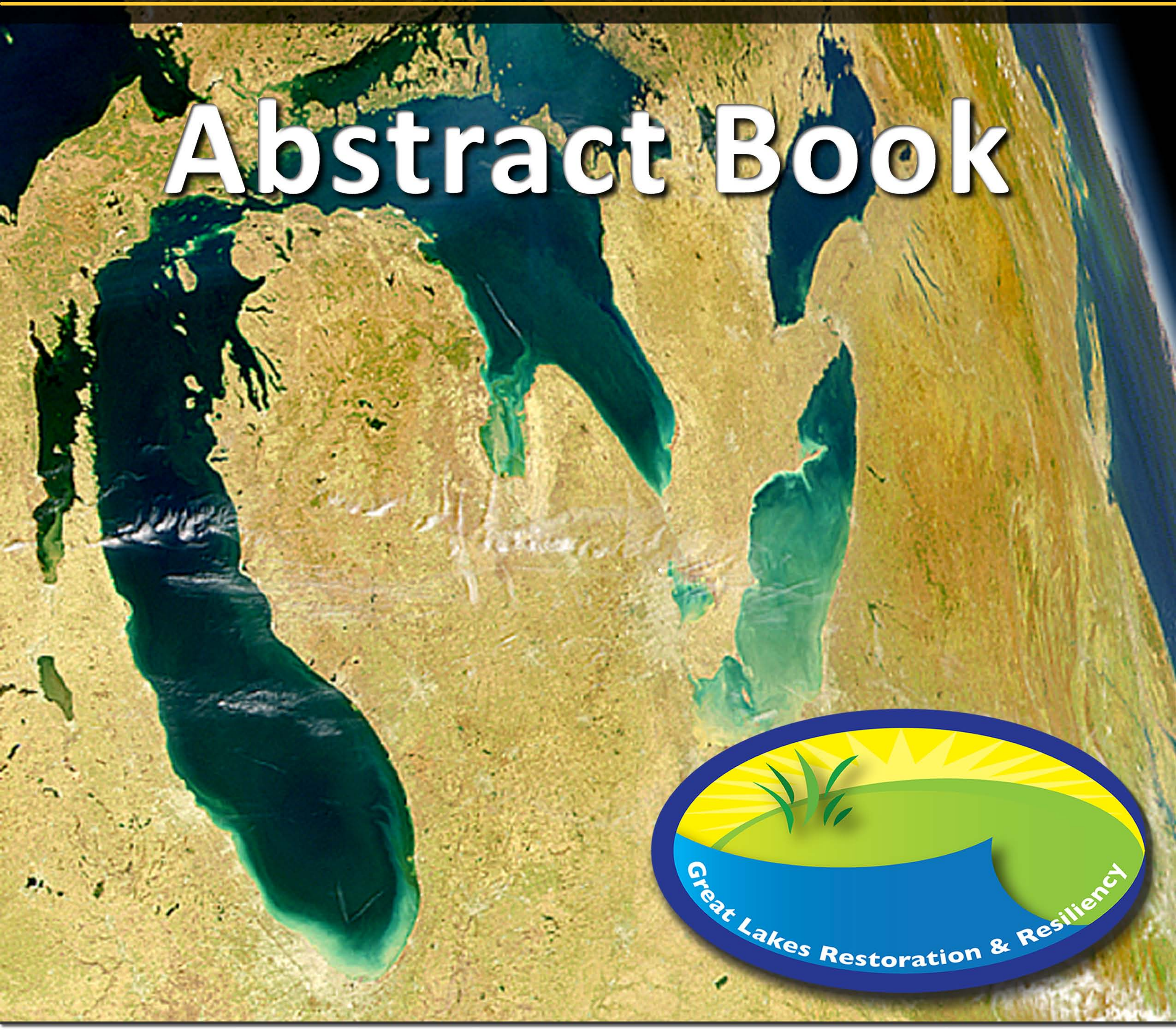
56th Annual Conference on Great Lakes Research

June 2 - 6, 2013
West Lafayette, Indiana



Abstract Book

Great Lakes Restoration & Resiliency

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Great Lakes Restoration and Resiliency

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ABDEL-MONEIM, A., MAHAPATRA, C.T., and SEPULVEDA, M.S., 264 Marstellar St, West Lafayette, IN, 47906. **Expression of genes involved in sex differentiation across several developmental stages in Japanese medaka (Oryzias latipes).**

Sex determination and differentiation in teleosts is controlled by several proteins, expressed during early development.In Japanese medaka (Oryzias latipes),sex is chromosomally determined.Although a lot is known regarding sex differentiation in this species, little is known regarding the impact of endocrine disrupting chemicals (EDCs) on sex differentiation.The long term goal of our studies is to determine the early molecular effects of EDCs on genes involved in sex differentiation and how the change in expression pattern is predictive of effects later in life (e.g. sex reversal).To be meaningful, one first needs to understand the baseline expression of genes during early development.Thus, we report the pattern of expression of three female sex specific genes: ovarian specific protein 1, osp1; aromatase, cyp19a; and vitellogenin,vtg.Gene expression was quantified at 5, 8, 10, 12 and 15 days post fertilization (dpf) using the SK2MC strain.In this strain,males are easily distinguishable by the presence of leucophores.All three genes were expressed at low levels in both the genders as early as 5 dpf; however at 15 dpf,expression was several folds higher in females (osp1 ~60-fold; vtg ~35-fold; and cyp19a ~20-fold) compared to males.Our results are in agreement with the reports that indicate oogenesis begins at ~15 dpf in medaka. *Keywords: Endocrine disruption, Sexual Differentiation, Genetics.*

ABMA, R.A., HAFFNER, G.D., and PATERSON, G., Great Lakes Institute for Environmental Research, 401 Sunset Ave., Windsor, ON, N9B 3P4. **Tissue Distribution of Hg in Yellow Perch During a 1-year Reproductive Cycle.**

The bioaccumulation of Hg in freshwater fish is widely studied as it is important to understand how Hg moves through the food web. One key parameter of the Hg bioaccumulation model is elimination, which is often accompanied by tissue redistribution. The role of reproduction in the elimination and tissue redistribution of Hg in fish is not yet well understood. We investigated this by collecting 3 size classes of yellow perch from Lake Erie at 10 time points during a 1 year reproductive cycle. Each individual was sacrificed and dissected and its organs and tissues (liver, muscle, gonads, stomach and fat) were collected for analysis. The remaining fish carcass from each individual was homogenized and also kept for analysis. Mercury concentrations in each organ/tissue were determined using DMA-80 and were calculated in mg/kg wet weight. The goal of this study was to determine whether Hg was eliminated during reproduction (ie, whether Hg was present in greater concentrations in the gonad tissue than in others) or if it was redistributed among the rest of the organs. The results of this study will help to establish the role that reproduction plays in the elimination of Hg from freshwater fish. *Keywords: Lake Erie, Reproduction, Yellow perch, Mercury.*

ADAMS, J.[1], CHERWATY-PERGENTILE, S.[2], HINCHEY MALLOY, E.[1], HORVATIN, P.[1], HYDE, R.[2], RODRIGUEZ, K.[1], STADLER-SALT, N.[2], and TEPAS, K.[3], [1]U.S. Environmental Protection Agency, Great Lakes National Program Office, Chicago, IL, 60604; [2]Environment Canada, Great Lakes Issue Management and Reporting Section, Burlington, ON, L7R 4A6; [3]Illinois-Indiana Sea Grant, University of Illinois, Urbana, IL, 61801. **Overview of Great Lakes Conditions and Trends II: State of Great Lakes Aquatic-Dependent Life.**

An overview of current Great Lakes aquatic-dependent life conditions and trends will be presented. The overview is derived from indicator reports prepared by scientists from over two dozen organizations, for the 2011 State of the Lakes Ecosystem Conference (SOLEC), organized by Environment Canada and the United States Environmental Protection Agency. Status and trends to be discussed include abundances of Diporeia, oliogchaetes, preyfish, Walleye, Lake Sturgeon, Lake Trout, and condition of coastal wetland amphibians, birds and plants.
Keywords: Decision making, Ecosystem health, Indicators.

ADLERSTEIN, S.[1], RISENG, C.M.[1], CARTER, G.[1], and WARREN, G.J.[2], [1]University of Michigan, 440 Church St, Ann Arbor, MI, 48109; [2]US EPA Great Lakes National Program Office, Chicago, IL, 60604. **Benthic Population trends in the Great Lakes and Perspectives on Nearshore Sites Influenced by Dreissena and Great Lakes Tributaries.**

The U.S. EPA has monitored the summer benthos at 10 to 16 stations in each of the five Laurentian Great Lakes since 1997. We examined temporal and spatial trends in density by lake and station. Temporal trends indicate declines in Sphaeriidae and *Diporeia* in Michigan, Huron and Ontario, but no trends were observed in any Lake for oligochaetes and chironomids. The losses of Diporeia in Michigan, Huron, and Ontario food webs have not been replaced by other benthic groups except for *Dreissena*. Several shallower stations relatively near to shore and located near tributaries, had generally higher densities of tubificids and dreissenids and shifts in species composition suggesting an increase in eutrophic conditions at shallower depths. Spatial patterns suggest that rivers influence may enhance densities of both dreissenids and tubificids at some of the nearshore sites in Lake Huron, southern Lake Michigan, and Lake Ontario. Dreissenids at high densities may enhance conditions for certain groups but this effect is not uniform. Changes in specific taxa were also not uniform; *Stylodrilus heringianus* densities declined at some sites in Lakes Michigan and Ontario and *Spirosperma ferox* declined at sites in Lake Ontario while composition was stable at other sites. *Keywords: Great Lakes basin, Benthos, Monitoring.*

ADLERSTEIN, S.[1], KAO, S.[1], and RUTHERFORD, E.S.[2], [1]University of Michigan School of Natural Resources and Environment, Dana Bldg, Church St, Ann Arbor, MI, 48109; [2]NOAA GLERL, 4840 S. State St, Ann Arbor, MI, 48108. **Nutrient Tipping Points for Great Lakes nearshore food webs: an Ecopath with Ecosim analysis.**

We used the Ecopath and Ecosim model to analyze changes in the Saginaw Bay, Lake Huron food web and fisheries caused by nutrient loadings and invasive species. We configured

the food web model with pre-Dreissena (1990) data on organism biomass, production, consumption and diet using survey data from NOAA GLERL, Michigan DNR and other sources. We conducted 50 year simulations of varying levels of phosphorus loadings, in combination with presence/absence of alewife and dreissenids to determine an ecological tipping point for walleye and yellow perch harvest. Under observed nutrient loads, although Dreissena severely affected phytoplankton and zooplankton biomass, its effects on fish biomass were relative minor compared to alewife which impacted young fish survival. Under recent conditions of no alewife, average nutrient loadings and reduced Dreissena biomass, model results indicate walleye harvest in Saginaw Bay meets management objectives for Lake Huron. At reduced nutrient levels, simulations suggest walleye harvests will decrease by >50% under different levels of Dreissena and alewife abundances. Our results suggest current nutrient load targets should be revised to sustain existing walleye harvests given food web changes caused by invasive species.
Keywords: Fisheries, Coastal ecosystems, Phosphorus.

ADLERSTEIN, S.[1], KAO, Y.C.[1], RUTHERFORD, E.S.[2], and ZHANG, H.[2], [1]440 Church Street, 3010 Dana, Ann Arbor, MI, 48109; [2]4840 S. State Rd. Ann Arbor, MI, 48108. **Relative impacts of nutrient loadings and invasive species on a Great Lakes food web: an Ecopath with Ecosim analysis.**

We used the Ecopath and Ecosim model to analyze changes in the Saginaw Bay, Lake Huron food web and fisheries caused by invasive species and nutrient loadings. We configured the food web model with pre-Dreissena (1990) data on organism biomass, production, consumption and diet using survey data from NOAA GLERL, Michigan DNR and other sources. We conducted 50 year simulations of single factors (nutrients, alewife, and dreissenids) and their combinations. Under observed nutrient loads, although Dreissena severely affected phytoplankton and zooplankton biomass, its effects on fish biomass were relative minor compared to alewife which impacted young fish survival. Dreissena had little effect on fish because chironomids, a main component of fish diets, fed mostly on detritus and were not affected by dreissenids. Under recent conditions of no alewife, average nutrient loadings and reduced dreissenids biomass, model results indicate walleye harvest in Saginaw Bay meets management objectives for Lake Huron. At reduced nutrient levels, simulations suggest walleye harvests will decrease by more than 70% under different levels of dreissenid and alewife abundances. Our results suggest nutrient load targets established in 1978 might not be able to sustain current walleye harvest given food web changes caused by invasive species.
Keywords: Alewife, Algae, Ecosystem modeling.

AHMED, S. and TROY, C.D., Purdue University School of Civil Engineering, 550 Stadium Mall Drive, West Lafayette, IN, 47907-2051. **Numerical simulations of fundamental internal Poincaré modes in Lake Michigan.**

Internal Poincare waves dominate currents in most of Lake Michigan for much of the stratified period. Simplified models have been developed in the past to derive the spatial structure of these waves, mostly for flat-bottomed lakes with simplified shapes. To identify the

spatial structure of the dominant Poincare modes in Lake Michigan, simulations with the 3-D hydrodynamic model SUNTANS were performed and analyzed for different representative thermal stratifications. Both idealized and historical simulations were performed. The dominant mode shapes were determined from the analysis, showing that a combination of a whole-basin mode and a two-basin mode dominate the Poincare response. The corresponding surface currents, bottom currents, and thermocline shear were mapped for this response. Surface currents and thermocline shear induced by the waves are seen to be largest in the center of the northern and southern lake basins, whereas bottom currents show only weak modulation with bathymetry.
Keywords: Lake Michigan, Poincare, Waves, Near-inertial, Hydrodynamic model, Shear.

AKRAM, A.C., MONIRI JAVID, R., SINGH, S.B., REED, E.A., GIZICKI, J.P., NOMAN, S., BASU, A.S., and RAM, J.L., Wayne State University, Detroit, MI, 48201. **Automated Testing Device for Live-Dead Analysis of Ballast Water Organisms.**

Methods for verifying ballast water treatments are needed to protect the Great Lakes from discharge of live non-native organisms or pathogens. Here we describe prototypes for automated viability testing using fluorescein diacetate (FDA), a membrane permeable fluorogen, to differentiate live from dead bacteria and algae. An automated system captured lab cultured, environmental, or ballast organisms on 0.2 um filters, backwashed them with buffer and FDA for subsequent fluorescence measurements, and washed the filters with sterile water for serial automated reuse. Preliminary manual versions of these procedures were also tested. Fluorescence in the presence of live organisms increased linearly over time and decreased linearly with sample dilutions (r2=0.92). After plankton and ballast water treatment with heat or chlorine, fluorescence was greatly decreased, to levels near control (sterile water). Cost reductions in the detection system included changing from fluorescence plate reader (>$20,000), to a fiber optics spectrometer (~$5,000), to recent electronic prototypes costing *Keywords: Ballast, Bacteria, Algae, Fluorescein diacetate, Measuring instruments, Detroit River.*

ALANI, R.A.[1], OLAYINKA, K.O.[1], DROUILLARD, K.G.[2], and ALO, B.I.[1], [1]Chemistry Department, University of Lagos, Nigeria, Africa; [2]Great Lakes Institute for Environmental Research (GLIER), University of Windsor, Windsor, ON. **Pattern of persistent, bioaccumulative and toxic (PBT) chemicals signatures across different media in Lagos lagoon.**

As a result of urban proliferation and industrial establishments in Lagos, untreated complex mix of possible (PBT) chemicals To assess the effect of this variation on the PBT distribution across different media at different locations, Lagos lagoon was sampled for PBTs in water, sediment, fishes and invertebrates in six locations and analysed using Gas chromatography/ Mass selective Detector (GC/MSD). For water, highest mean PAHs of 0.080ng/ml was obtained at the mouth of Ogun River while highest mean OCs of 0.069ng/ml was obtained at Okobaba. No PCB was detected in the water samples. For sediments, highest mean PAH of 68.251ng/g. d. w. was obtained at Okababa; highest mean OCs of 11.859 and 4.420ng/g d. w. were obtained at Aja and Okobaba respectively; and highest mean PCB of 1.331

and 1.044ng/g d. w. were obtained at the mouth of Ogun River and Aja respectively. For the invertebrates, highest mean PAH of 18.659ng/g d. w. was obtained in crayfish; highest mean PCB of 17.070ng/g d. w. was obtained in crayfish; and highest mean OC of 13.880ng/g d. w. was obtained in young crabs. For fishes, highest mean PAH of 28.996ng/g d. w. was obtained in agaza; highest mean PCB of 1.925ng/g d. w. was obtained in mullets. *Keywords: Estuaries, Water quality, PBTs.*

AMBERG, J.J., MCCALLA, S.G., and GAIKOWSKI, M.P., USGS - Upper Midwest Environmental Sciences Center, La Crosse, WI, 54603. **Unmuddying waters of environmental DNA: Importance of understanding birds as vectors of DNA transfer.**

The use of environmental DNA (eDNA) has great promise as a tool for management and regulatory agencies to quickly detect the presence or absence of invasive species or pathogens. Environmental DNA is currently used to monitor for the presence of Asian carp, bighead carp (Hypophthalmichthys nobilis) and silver carp (H. molitrix), throughout the Chicago Area Waterway System (CAWS), Great Lakes and Upper Mississippi River. However, detection of Asian carp DNA in an eDNA sample only indicates the presence of DNA, not the route of entry of that DNA into the sampled environment. Vectors and fomites of DNA transmission from locations where Asian carp are present to locations where Asian carp are not present have generally not been evaluated. Characterizing the potential of vectors or fomites to transfer DNA is critical to accurate interpretations of DNA detected in environmental samples. Piscivorous birds were examined to determine their capacity to transfer Asian carp DNA through fecal contamination. We demonstrate that silver carp DNA can be amplified from the feces of piscivorous birds fed silver carp. We will also provide approaches to eliminate the detection of Asian carp DNA from birds, which may aid in the interpretation of eDNA data by resource managers. *Keywords: Invasive species, Monitoring, Biological invasions.*

AMBERG, J.J., LUOMA, J.A., HUBERT, T.D., and GAIKOWSKI, M.P., USGS - Upper Midwest Environmental Sciences Center, La Crosse, WI, 54603. **Development of new tools to control the filter-feeding Asian carps.**

Invasive silver carp Hypophthalmichthys molitrix and bighead carp H. nobilis currently threaten the Great Lakes. Resource managers are presently limited to non-specific piscicides (e.g. rotenone, antimycin-A) for chemical control of these aquatic invaders. Development of management controls that are more "carp-specific" is of high priority for research managers. One potential method seeks to exploit the planktivorous feeding habits of Asian carp through delivery of bioactive compounds captured within a targeted microparticle delivery system. Using technologies developed for the aquaculture and food industries, microparticles that require specific digestive enzymes for bioactive release bioactive are presently under development to selectively deliver control agents to Asian carp. We present a comparison of Asian carp gill raker anatomy and digestive function relative to native planktivorous fishes as well as information on microparticle acceptance by Asian carp. Results suggest that these microparticles, especially when coupled with other tools such as aggregating pheromones or feeding stimulants, have the

potential to deliver selected bioactive agents to Asian carps and other filter feeding aquatic invasive organisms for population management. *Keywords: Invasive species, Biological invasions, Management.*

ANDERSON, C., BÉDARD, M.O., CLICHE, B., LABERGE, B., and ST-PIERRE, M., Ministère du Développement durable, de l'Environnement, de la Faune et des Parcs, 675, Boul. René-Lévesque Est, 8e étage, Québec, QC, G1R 5V7. **Cumulative Impact Assessment of Water Withdrawals in Quebec: Better Protect and Conserve Water Resources of the Great Lakes-St. Lawrence River Basin.**

In 2005, Québec signed the Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement (Agreement) with another Canadian Province (Ontario) and eight US states (llinois, Indiana, Michigan, Minnesota, Ohio, New York, Pennsylvania, and Wisconsin). By signing this agreement, Québec committed to, among other things, assessing the cumulative impacts of water withdrawals on the quantity and quality of the Waters and Water Dependent Natural Resources of the Basin at the jurisdictional scale. This presentation provides an overview of the approach under development in Quebec, including how the methodology is being developed, and how it should be implemented. *Keywords: Legislation, Cumulative Impact, Assessments, Water Withdrawals, Environmental effects.*

ANDERSON, E.J.[1] and SCHWAB, D.J.[2], [1]NOAA/GLERL, 4840 S. State Rd, Ann Arbor, MI, 48108; [2]University of Michigan, Water Center, Ann Arbor, MI, 48104. **Modeling the Oscillating Bi-Directional Flow at the Straits of Mackinac.**

The Straits of Mackinac is the connecting waterway between Lakes Michigan and Huron, providing a net flow on the order of 1000 m3/s. However, observations have shown that the bi-lake seiche induces oscillating flow conditions at the Straits resulting in discharges up to 80,000 m3/s with a period of just over 2 days. Currently, the Great Lakes Coastal Forecasting System (GLCFS) uses two separate models for Michigan and Huron, where a solid boundary at the Straits restricts exchange flow between lakes. In this work, a hydrodynamic model of the combined Lake Michigan-Huron is developed to investigate flow at the Straits, providing the ability to forecast flow direction and magnitude in real-time. The model is based on the Finite Volume Coastal Ocean Model (FVCOM), and has been calibrated to ADCP measurements at the Straits and measurements from other locations. Results show that the model is able to predict flow direction with 28% uncertainty and magnitude within 20%. In addition, the combined-lake model shows that an "open-Straits" condition affects currents within 80 km of the Straits as well as in the deepest areas of Lake Michigan (Chippewa Basin) and Lake Huron (Manitoulin Basin), as compared to the present GLCFS models. This influence on hydrodynamics can have important implications for spill prediction and water quality. *Keywords: Hydrodynamic model, Straits of Mackinac, Lake Michigan, Lake Huron.*

ANDERSON, J.D. and WU, C.H., 1261 Engineering Hall, 1415 Engineering Drive, Madison, WI, 53706. **Development of a nested wave prediction model for Great Lakes.**

Third-generation wave prediction models are currently operating for most of the U.S. coastal waters and the Great Lakes. These models can cover extensive areas but may not be capable of resolving detailed nearshore wave properties that are affected by bottom bathymetry, islands, or coastal structures. One potential strategy is to employ a set of nesting grids to obtain a higher spatial resolution to resolve wave transformation at the local scale. In this study, we use a third-generation wave model, SWAN, and a parametric type Donelan wave model (Schwab et al, 1984, 1988) to examine complex wave processes in the Apostle Islands, Lake Superior. Two criteria, accuracy and implementation, will be posed to evaluate the two type of models. Accuracy is based on significant wave height and comparisons of each model's capability to simulate nearshore wave processes like refraction, shoaling, and diffraction. Implementation considerations include computational efficiency and required computational resources necessary to implement a nested forecast model. In addition, we discuss the process of implementing boundary conditions to a nested model using available model wave data. Overall our goal is to develop an efficient and effective nested grid-based wave model for accurately and reliably predicting wave climate in the Great Lakes. *Keywords: Model testing, Waves, Hydrodynamics.*

ANDERSON, M.R., DEKEL, N.D., KANG, M., GIBBONS, S., and COLEMAN, M.L., Department of Geophysical Sciences, University of Chicago, Chicago, IL, 60637. **Microbial Community and Population Diversity in the Laurentian Great Lakes.**

Marine and freshwater microbial communities play fundamental roles in the biogeochemical cycling of carbon, nitrogen, and phosphorus. These communities are incredibly diverse, not only at the level of species richness, but also at finer scales within a given taxonomic group. However, the factors controlling this diversity, and its importance for ecosystem functioning and resilience, remain unclear. The Laurentian Great Lakes exhibit within- and between-lake variations in bathymetry, organic and inorganic nutrient inputs, and human impacts providing a natural laboratory to test factors controlling community- and population-level diversity. We present initial results from a new metagenomic and metatranscriptomic time series in all five Laurentian Great Lakes including an examination of taxon-specific biases associated with sampling and nucleic acid extraction methods, as well as comparisons of microbial community and population structures of two of the Great Lakes with each other and with better characterized marine and small lake communites. We found high diversity even at the phylum level, and many of the abundant bacterial taxa we observed are poorly characterized in aquatic systems. Ongoing genomic and physiological studies will help elucidate the functional roles of these taxa in large lake systems. *Keywords: Biodiversity, Biogeochemistry, Ecosystems.*

ANDREE, S.R., BLEDSOE, J.W., CRAGUN, A.M., FEINER, Z.S., and HÖÖK, T.O., 195 Marstellar St., West Lafayette, IN. **Maternal Effects on Egg and Larval Quality in Yellow Perch (Perca flavescens).**

Variation in maternal characteristics of fish, such as size and age, may greatly influence key offspring traits (e.g., size) and performance (e.g., early life stage survival). Yellow perch (Perca flavescens) are an integral part of many freshwater ecosystems and in the Great Lakes yellow perch populations display broad size and age structures. Thereby, maternal characteristics may influence intra- and inter-population variation in reproductive potential of Great Lakes yellow perch. We reared and spawned yellow perch in a controlled laboratory environment and quantified relationships between maternal traits (length, weight, and age) and metrics of offspring quality (egg size, larval size, and larval survival). Positive correlations between maternal traits (size and age) and egg size metrics were evident, but relationships between maternal characteristics and larval size metrics were not. Larval survival appeared to have two critical periods. Survival in the first five days post-hatch was strongly negatively correlated with female size and age, while survival over the following nine days was positively related to egg size. This exploration of some lesser-studied facets of maternal influence offers unique implications for both management and rearing of this and other freshwater fish species.
Keywords: Fish, Maternal effects, Percids, Fish populations.

ANKNEY, M.M.[1], HIGMAN, P.[2], TANGORA, S.[1], and WALTERS, K.[1], [1]Michigan Department of Natural Resources, 8562 East Stoll Road, East Lansing, MI, 48823; [2]Michigan Natural Features Inventory, East Lansing, MI, 48823. **Mounting a Response to New Aquatic Invaders.**

The Michigan Department of Natural Resources, Wildlife Division, is currently leading a Great Lakes Restoration Initiative grant project for aquatic invasive species in Michigan. The first goal of this project is to develop a state-wide Early Detection Rapid Response program through revision and implementation of the Michigan Aquatic Invasive Species State Management Plan (led by the MI Dept of Environmental Quality). Progress on developing this program is being collaborated on by many state agency partners, including many divisions within the Michigan Departments of: Environmental Quality; Natural Resources; and Agriculture and Rural Development. The second goal of this grant project is to eradicate/control six to eight high threat aquatic invasive plant species in Michigan. Six species are listed specifically in the grant due to low distribution levels which are documented in previous research projects and other data sources. Verifying these occurrences and conducting response actions is currently underway, and has relied primarily upon science based decision making processes. Analysis of these species' current distribution, an improved understanding of their impacts, and evaluating our response effectiveness are all ongoing, and will provide enhanced decision making into the future.
Keywords: Invasive species, Great Lakes Restoration Initiative (GLRI), Management.

ARHONDITSIS, G.B., University of Toronto, 1265 Military Trail, Toronto, ON, M1C 1A4.
Useless Arithmetic? Lessons Learned and Future Perspectives of Aquatic Biogeochemical Modeling.

What is the capacity of the current models to simulate the dynamics of environmental systems? How carefully do modellers develop their models? How rigorously do we assess what a model can or cannot predict? The first part of my presentation aims to answer some of these questions by reviewing the state of aquatic biogeochemical modelling; a research tool that has been extensively used for understanding and quantitatively describing aquatic ecosystems. The second part of my presentation argues that the development of novel methods for rigorously assessing the uncertainty underlying model predictions should be a top priority of the modelling community. In this context, I will illustrate how the Bayesian inference techniques can be used to obtain robust predictions, while explicitly accounting for the associated model uncertainty. Some of the benefits of the Bayesian approach, such as the rigorous assessment of the expected consequences of different management actions, the alignment with the policy practice of adaptive management, and the ability to sequentially update the existing models and therefore serve as long-term management tools for the studied systems are particularly useful for stakeholders and policy makers when making decisions for sustainable environmental management. *Keywords: Model testing, Bayesian inference, Ecosystem modeling, Model studies.*

ARIFIN, R.R.[1], DE ALWIS PITTS, D.A.[2], SHARMA, A.[1], JAMES, S.C.[3], FERNANDO, H.J.[1], and SUHARDJO, A.[2], [1]Department of Civil & Environmental Engineering and Earth Sciences, University of Notre Dame, Notre Dame, IN, 46556; [2]Center for Research Computing, University of Notre Dame, Notre Dame, IN, 46556; [3]Exponent, 5401 McConnell Avenue, Los Angeles, CA, 90066. **Modeling the Formation and Propagation of Thermal Bar in Lake Ontario.**

The formation of thermal bars is an important phenomenon in large, dimictic, temperate lakes. This study is motivated by concerns on nearshore lake health caused by downwelling of dense water at the thermal bar, which acts as a barrier to horizontal mixing. Decreased horizontal mixing reduces the exchange of nutrients, alters habitats of aquatic species, and may intensify eutrophication (algal blooms). Thermal bar formation and their propagation through Lake Ontario are simulated using the 3D hydrodynamic model - Environmental Fluid Dynamics Code (EFDC). The model uses as inputs the hourly meteorological data from seven weather stations around the lake, flow rate and water temperature data for the Niagara and St. Lawrence Rivers, and lake bathymetry data. The simulation is performed for the year 2011, February to August, on a curvilinear grid at 2-km resolution. Comparison of simulated results with remotely sensed surface-temperature data demonstrates that the hydrodynamic model successfully replicates the primary features of hydrothermal behaviors of the lake. *Keywords: Hydrodynamic model, Thermal bar, Remote sensing, Lake Ontario.*

ARMENIO, P.M., WATSON, N.M., DAVIS, B.M., and BUNNELL, D.B., USGS Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105. **Lake Huron Zooplankton Communities: Any Changes Between 2007 and 2012?**

Lake Huron underwent many changes between 2002 and 2006, including declines in the biomass of Chinook salmon, prey fish, cladoceran and and cyclopoid zooplankton, and *Diporeia* spp. The importance of top-down versus bottom-up processes in driving these changes remains a research focus. Herein, we evaluated whether the zooplankton community has changed between 2007 and 2012 using monthly, whole-water column samples collected from northern Lake Huron. Over this period, prey fish biomass has increased, particular for planktivorous bloater. In 2007, the community was consistent with an oligotrophic lake: larger biomass of calanoid copepods relative to cyclopoid copepods or cladocerans. Preliminary results for Lake Huron zooplankton community composition from April-October 2012 suggest that no drastic changes have occurred. *Leptodiaptomus* spp. dominated throughout the year, while cladoceran (i.e. *Daphnia galeata mendotae*, *Bosmina longirostris*, and *Holopedium gibberum*) biomass and *Epishura lacustris* became relatively abundant in late summer. Hence, cladoceran and cyclopoid copepod biomass do not appear to have rebounded; comparisons of total zooplankton biomass will be made. Zooplankton in Lake Huron may be stabilizing from the recent food web changes in the previous decade. *Keywords: Food chains, Zooplankton, Lake Huron.*

ASSEL, R.[1], WANG, J.[2], CLITES, A.[2], and BAI, X.[1], [1]University of Michigan CILER, 4840 S State Road, Ann Arbor, MI, 48108; [2]NOAA GLERL, 4840 S State Road, Ann Arbor, MI, 48108. **Analysis of Great Lakes Ice Cover Climatology: Winters 2006-2011.**

A 33-winter ice concentration climatology (Assel 2003a, Assel 2005a) was recently updated for winters: 2006-2011 (Wang et al, 2012a). This staudy provides an analysis of the 2006-2011 ice cycles within the context of: dates of first (last) ice, ice duration, ice cover distribution, ice cover anomalies and seasonal progression of lake averaged ice cover. Sea ice response to a changing climate is discussed. *Keywords: Ice, Climatology, Climatic data.*

AUCH, J.[1], MUND, G.[2], and TISUE, T.[2], [1]Muskegon Conservation District, 940 N Van Eyck St, Muskegon, MI, 49442; [2]White Lake Public Advisory Council, 4388 Duck Lake Road, Whitehall, MI, 49461. **The White Lake, Michigan, Area of Concern.**

White Lake is the terminus of a 140 kha watershed where logging's devastation was followed by 150 years of insults from a tannery, municipal wastes, foundry operations, and chemical manufacturing facilities. Degraded habitat and a huge burden of organic wastes, metals, and toxic chemicals led to designation as an AOC. The 'world's largest weather vane' stands near the lakeshore, but by 1971, when Life's photos showed the lake's sorry state, those living nearby did not need a weather vane to know which way the wind was blowing. From this low point, driven by the dedication and persistence of local citizens and their elected representatives, things started to change. Scientific studies catalogued the extent of pollution and habitat degradation, leading to decades-long remediation and restoration activities. Recent Federal grants addressed

lingering habitat issues, a key step. Now, four of eight original BUIs are resolved and three more nearly so. Only groundwater contamination issues impede White Lake's de-listing. When delisting comes, it will represent the culmination of efforts by many individuals and organizations, with funding from several sources, and through the implementation of sound scientific and engineering solutions. This presentation analyzes the factors leading to this imminent success. *Keywords: Remediation, Area of concern, Great Lakes Restoration Initiative (GLRI), Remedial action plans, Public participation.*

AUER, M.T.[1] and LAMBERT, R.S.[2], [1]Great Lakes Research Center, Michigan Technological Unversity, Houghton, MI, 49931; [2]LimnoTech, Inc., 501 Avis Drive, Ann Arbor, MI, 48108.
Phosphorus Bioavailability in the Major U.S. Tributaries to the Great Lakes.

The nearshore water of the Great Lakes are receiving renewed attention with respect to eutrophication. Excess phosphorus loads and dreissenid re-structuring of phosphorus cycling have been implicated in the occurrence of HABs and nuisance growth of Cladophora. While it is known that phosphorus is the nutrient limiting Cladophora growth, the availability of the various forms of phosphorus to support that growth is not well defined. Chemical and algal assay technologies are available that may used to quantify the bioavailability of the three analytical-defined forms: particulate (PP), dissolved organic (DOP) and soluble reactive (SRP) phosphorus. Here, we report on assays performed on water samples collected from the five largest U.S. tributary sources of phosphorus to the Great Lakes: the Cuyahoga, Sandusky and Maumee Rivers in Ohio, the Saginaw River in Michigan and the Fox River in Wisconsin. On average, 36% of the particulate P, 67% of the DOP and 100% of the SRP was determined to be bioavailable. Considerable variation in bioavailability was noted, however, between sites and temporally at a given site. The significance of these findings in developing phosphorus management strategies and in targeting sites for nonpoint and point source control of phosphorus is discussed. *Keywords: Phosphorus, Nonpoint, Algae, Bioavailablity, Management.*

AUSTIN, J.A., Large Lakes Observatory, 2205 E. 5th St, Duluth, MN, 55812. **Observations of near-inertial energy in Lake Superior.**

Directly measured velocity data collected in Lake Superior between 2008 and 2011 show that currents in the open waters of the lake are dominated by near-inertial energy. The near-inertial signal is composed almost entirely of clockwise rotation, with vertical structure dominated by the first baroclinic mode, where waters above and below the thermocline are roughly 180° out of phase with each other. The strength of the oscillations is strongly related to the strength of the stratification; in periods of the year when the water column is well mixed (typically late fall and late spring) the near-inertial signal is very weak; when stratification exists, near-inertial oscillations can occur. Combining the velocity amplitudes with an estimate of the thermocline displacement allows estimation of the dominant direction and horizontal wavelength of the near-inertial field, showing that horizontal wavelengths are on the order of 50-100 km, and the direction of the waves veers counter-clockwise over the course of the season with a period of approximately 1 month. Observations of backscatter suggest that inertial oscillations may be

responsible for resuspension of bottom sediments, which could have significant ecological consequences. *Keywords: Hydrodynamics, Inertial oscillations, Waves, Lake Superior.*

AWAD, A.M., MARTINEZ, A., HU, D., MAREK, R.F., KOH, W., and HORNBUCKLE, K.C., 4105 Seamans Center, Iowa City, IA, 52242. **Particulate PCBs and OH-PCBs in Chicago Air.**

Since 2006, we have conducted a monitoring study of airborne polychlorinated biphenyl (PCB) congeners in the city of Chicago using both passive and active samplers. Between 2006 and 2009, we collected air samples using high volume air samplers (HI-Vols) equipped with quartz fiber filters (to collect airborne particles) and XAD resin (to collect gas phase PCBs). We have previously reported on our analyses of gas phase PCB concentrations. Here we report the concentrations and congener distribution of PCB congeners bound to particulates collected on the filters used in those same Hi-Vols. In addition, we have developed an analytical method to analyze hydroxylated PCB congeners (OH-PCBs) in the particulate phase. We hypothesized that OH-PCBs are more likely to be present in the particulate than in the gas phase due to their physical-chemical properties. To evaluate this hypothesis, we have chosen a sample set from twenty locations (each with over 15 samples) in the city of Chicago collected from 2007 through 2009. Because the OH-PCB levels are quite low, some samples from the same location and year have been combined, resulting in integrated PCB and OH-PCB concentrations over specific spatial and temporal ranges. *Keywords: Toxic substances, Chicago, PCBs.*

BAI, X.[1], WANG, J.[2], SCHWAB, D.J.[2], YANG, Y.[3], LUO, L.[2], LESHKEVICH, G.[2], and LIU, S.[2], [1]CILER, University of Michigan, 4840 South State Rd., Ann Arbor, MI, 48108; [2]NOAA/Great Lakes Environmental Research Lab., 4840 South State Rd., Ann Arbor, MI, 48108; [3]Hainan Marine Development and Design Institute, Haikou, China. **Modeling 1993-2008 climatology of seasonal general circulation and thermal structure in the Great Lakes using FVCOM.**

An unstructured Finite Volume Coastal Ocean Model was applied to all five Great Lakes simultaneously to simulate circulation and thermal structure from 1993 to 2008. Model results are compared to available observations of currents and temperature and previous modeling work. Maps of climatological circulation for all five Great lakes are presented. Winter currents show a two-gyre type circulation in Lakes Ontario and Erie and one large-scale cyclonic circulation in Lakes Michigan, Huron, and Superior. During the summer, a cyclonic circulation remains in Lakes Superior; a primarily cyclonic circulation dominates upper and central Lake Huron; Lake Ontario has a single cyclonic circulation, while circulation in the central basin of Lake Erie remains two-gyre type; Lake Michigan has a cyclonic gyre in the north and an anti-cyclonic one in the south. The temperature profile during the summer is well simulated when a surface wind-wave mixing scheme is included in the model. Main features of the seasonal evolution of water temperature, such as inverse temperature stratification during the winter, the spring and autumn overturn, the thermal bar, and the stratification during summer are well reproduced. The lakes

exhibit significant annual and interannual variations in current speed and temperature. *Keywords: Hydrodynamic model, Great Lakes basin.*

BAKER, D.B., JOHNSON, L.T., CONFESOR, R.B., RICHARDS, R.P., ROERDINK, A.R., KRAMER, J.W., EWING, D.E., and MERRYFIELD, B.J., Heidelberg University NCWQR, 310 East Market Street, Tiffin, OH, 44883. **Bioavailable Phosphorus Loading to Lake Erie from the Maumee and Sandusky Watersheds: Trends and Management Implications.**

To assess trends in total bioavailable phosphorus (P) loading to Lake Erie from tributaries, it is necessary to track changes in both the amounts and bioavailability of particulate and dissolved P. By combining long-term loading studies (1975-2012) of total and dissolved reactive P with explicit studies of P bioavailability in 1980 and again in 2009-10, we are able to estimate long-term trends in total bioavailable P loading and its particulate and dissolved components. The portion of the particulate P that is bioavailable, as measured by NaOH extraction, has not changed and averages about 27%. Thus trends in bioavailable particulate P export follow trends in particulate P export, which have been slightly downward for the Maumee and upward for the Sandusky. While the portion of total dissolved P that is bioavailable (~96%) has increased slightly in both rivers, downward trends in dissolved P export from the mid-1970s to the mid-1990s and even larger upward trends since then characterize bioavailable dissolved P export from both rivers. The net effect is upward trends in total bioavailable P export from both rivers. Over the last 10 years, less than 50% of the total P loading from these rivers consists of bioavailable P, a reality that should be incorporated into future P target loads and P management plans. *Keywords: Phosphorus, Bioavailable Phosphorus, Lake Erie, Tributaries, Eutrophication.*

BAKKILA, K.A., VIJAYAVEL, K., and KASHIAN, D.R., Wayne State University, 5047 Gullen Mall, Detroit, MI, 48202. **Benthic Algae as a Contributing Source of Shoreline Bacterial Contamination.**

The filamentous benthic alga, *Cladophora glomerata*, is a concern in the Great Lakes region due to its impacts on recreational beach use and human health. Excessive growth and detachment of the algae results in their accumulation along the shoreline creating thick mats that are aesthetically displeasing, malodorous, and may harbor harmful bacteria. We examined the concentrations of *Escherichia coli* and enterococci from near-shore water, wet and dry algal deposits, and beach sand collected from a popular recreational beach in Saginaw Bay, MI, in 2010. We found high concentrations of *E. coli* and enterococci in wet algal deposits followed by the dry algal deposits, near-shore water, and beach sand. Transport of bacteria from shoreline algal deposits and sand to the water column was examined in laboratory microcosm experiments. Optimal growth conditions for *E. coli* and enterococci with reference to light, oxygen, temperature, and moisture was determined. Microcosm results showed significant *E. coli* transfer from wet algal deposits (p=0.02) and underlying sand (p= 0.03) to water column. Overall results suggest that the shoreline algae provides suitable environment for the bacteria to persist and

proliferate, thereby impacting near-shore water quality. *Keywords: Algae, Microbiological studies, Human health.*

BALDIGO, B.P., US Geological Survey, 425 Jordan Road, Troy, NY, 12180. **Toxicity of Waters from the St. Lawrence River Area-of-Concern to Two Plankton Species.**

The US and Canada committed to restore the chemical, physical, and biological integrity of the Great Lakes Ecosystem under the first Great Lakes Water Quality Agreement in 1972. During subsequent amendments, part of the St. Lawrence River at Massena NY, and segments of three local tributaries, were designated as one Area of Concern (AOC) due to several beneficial use impairments (BUIs). The plankton beneficial use was designated impaired within because plankton population data were unavailable. Contaminated sediments have been largely been remediated, therefore, the plankton BUI may now be obsolete. One criterion established by The St. Lawrence River AOC remedial action plan to address this BUI was, "in the absence of community structure data, plankton bioassays confirm no toxicity impact in ambient waters". Acute and chronic toxicity of water from 14 sites were quantified seasonally using standardized bioassays and the algae *Selenastrum capricornutum* and water flea *Ceriodaphnia dubia* to test the hypothesis that waters from AOC sites within were no more toxic than waters from control sites. Results confirm that ambient waters from most AOC sites (and seasons) were generally not toxic to both species and that surface waters in the AOC should not seriously impair the health of resident plankton communities. *Keywords: AOC, BUI, St. Lawrence River, Phytoplankton, Toxicity, Zooplankton.*

BALDRIDGE, A.K. and LODGE, D.M., Department of Biological Sciences, University of Notre Dame, Notre Dame, IN, 46556. **Intraguild predation between spawning smallmouth bass (*Micropterus dolomieu*) and nest-raiding crayfish (*Orconectes rusticus*): implications for bass nesting success.**

Complex interactions between nesting fish and egg predators may influence reproductive success in unexpected ways. The invasive rusty crayfish (*O. rusticus*) and smallmouth bass (*M. dolomieu*) engage in reciprocal predation (i.e., crayfish consume bass eggs and bass consume crayfish) during bass spawning season and the net impact on bass reproduction is poorly understood. We hypothesize that nest abandonment rates and bass guarding behaviors are positively related to crayfish abundance and that bass consumption of crayfish will mitigate energy loss due to nest guarding against crayfish. We used video surveillance to assess guarding behavior, reconstructed bass diets using fecal remains, and monitored weight and length for a subset of the parental bass. Nest abandonment rate and guarding activity were higher in areas with higher crayfish density. However, more than 95% of bass consumed crayfish and bass condition factor increased during nesting, suggesting that energy consumed exceeded energy expended to defend the nest. Further, the lakewide rate of smallmouth bass nest abandonment was relatively low at 13%. Contrary to the assumption that abundant nest predators can reduce fish nesting success, our findings indicate that consumption of crayfish could potentially mitigate rates of nest abandonment by bass. *Keywords: Invasive species, Micropterus, Crustaceans.*

BALDWIN, A.K.[1], SULLIVAN, D.J.[1], CORSI, S.R.[1], READ, J.S.[1], SCANLAN, D.P.[1], and LORENZ, D.L.[2], [1]U.S. Geological Survey, Wisconsin Water Science Center, Middleton, WI, 53562; [2]U.S. Geological Survey, Minnesota Water Science Center, Mounds View, MN, 55112.
A new network of continuous water-quality sensors to estimate nutrient and pollutant loads in Great Lakes tributaries.

In order to characterize baseline conditions and measure the success of restoration activities associated with the Great Lakes Restoration Initiative (GLRI), the U.S. Geological Survey (USGS) initiated a study to develop regression models to estimate real-time concentrations and loads of nutrients, suspended solids, and chloride in Great Lakes tributaries. Water-quality sensors and automated samplers were installed at 30 tributaries throughout the Great Lakes basin in 2010-11, colocated with existing National Monitoring Network for U.S. Coastal Waters sites. The sensors continuously measure water temperature, specific conductance, turbidity, dissolved oxygen, and pH (the explanatory variables). Discharge, another explanatory variable, is computed from continuous stream stage measurements. Discrete water-quality samples (~ 48 per year) are collected over a range of flow conditions and analyzed for nutrients, suspended sediment, and chloride (the response variables). Data will be published through the USGS National Real-Time Water Quality portal at http://nrtwq.usgs.gov/. These data will provide baseline conditions and aid in our understanding of nutrient and pollutant loads entering the Great Lakes, the water-quality impact of land management practices, and over the long term, the impact of GLRI and other restoration activities. *Keywords: Monitoring, Great Lakes Restoration Initiative (GLRI), Water quality.*

BALTHASAR, A.R.[1], EVANS, M.S.[2], MUIR, D.C.G.[3], and HINTELMANN, H.[4], [1]Trent University, Environmental and LIfe Sciences Graduate Program, 1600 West Bank Drive, Peterborough, ON, K9J 7B8; [2]Environment Canada, 11 Innovation Boulevard, Saskatoon, SK, S7N 3H5; [3]Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [4]Trent University, Department of Chemistry, 1600 West Bank Drive, Peterborough, ON, K9J 7B8.
Application of mercury stable isotope research to improve long-term fish monitoring studies of Great Slave Lake, NT, Canada.

Methylmercury bioaccumulation through food chains is of concern due to health risks associated with high levels of mercury (Hg) in high trophic level organisms, such as predatory fish. Monitoring of mercury in water bodies of Northern regions, such as Great Slave Lake, NT, Canada, is particularly important because their fisheries are a substantial food source to local communities. Long-term measurements suggest that Hg concentrations in fish, such as burbot, are increasing in the NWT. Mercury stable isotope analysis may improve monitoring of Hg through specific identification of local versus global inputs. Precise measurement of Hg isotope ratios is possible through the use of Multi-collector Inductively Coupled Plasma Mass Spectrometry (MC-ICP-MS). Our aim is to investigate how changes in Hg isotope ratios may relate to climate change, source changes or other geochemical processes over time and on a large lake scale, thus establishing baseline values for the region. Mercury stable isotope analyse has the potential to provide new and important information on sources and or processes of mercury contaminants in the environment and the effects of global warming on mercury contaminant

levels in Great Slave Lake fish. *Keywords: Mercury, Stable isotopes, Isotope studies, Biogeochemistry, Fish, Environmental contaminants.*

BANDA, J.A.[1], BLAZER, V.S.[2], CHOY, S.J.[3], GEFELL, D.J.[4], IWANOWICZ, L.R.[2], JORGENSON, Z.G.[5], LEE, K.E.[6], MAZIK, P.M.[7], MOORE, J.N.[8], and THOMAS, L.[5], [1]4625 Morse Rd., Ste. 104, Columbus, OH, 43230; [2]11649 Leetown Rd., Kearneysville, WV, 25430; [3]505 Science Dr., Ste. A, Madison, WI, 53711; [4]3817 Luker Rd., Cortland, NY, 13045; [5]4101 American Blvd. E., Bloomington, MN, 55425; [6]2280 Woodale Dr., Mounds View, MN, 55112; [7]P.O. Box 6125, 322 Percival Hall, Morgantown, WV, 26506; [8]2651 Coolidge Rd., Ste. 101, East Lansing, MI, 48823. **Early Warning Program to Detect and Identify Contaminants of Emerging Concern (CECs) and Their Effects to Fish and Wildlife.**

This study explores the concentration of approximately 150 select CECs within the Great Lakes basin and investigates impacts to fish and wildlife from these influences, particularly within Areas of Concern (AOC). AOC beneficial use impairments related to chemical pollution consist primarily of priority pollutants and legacy contaminants, but many AOCs also contend with endocrine active compounds and pharmaceuticals. In most AOC systems, little is known about the distribution, environmental concentrations, or biological effects of CECs. Surface water, sediment and resident fish samples were collected at multiple sites within seven AOCs. Water and sediment samples were analyzed for a select suite of pharmaceuticals, hormones, and other inorganic and organic wastewater indicators. Resident fish were weighed, measured, bled and necropsied in the field. Results are being analysed for correlations between the geographic differences in CEC concentrations and observed effects on resident fish, as well as the relationship between CEC concentrations and possible sources of contamination. Results will contribute to our understanding of how different landscapes influence varying concentrations and composition of CECs across the Great Lakes basin, along with how exposure to these compounds may affect fish and wildlife. *Keywords: Bioindicators, Contaminants of Emerging Concern, Endocrine disruption, Great Lakes basin.*

BARBIERO, R.P.[1], LESHT, B.M.[2], JOHENGEN, T.H.[3], RISENG, C.M.[4], and WARREN, G.J.[5], [1]CSC, 1359 W Elmdale Ave #2, Chicago, IL, 60660; [2]CSC and University of Illinois Chicago, 845 W Taylor St., Chicago, IL, 60607; [3]University of Michigan - Cooperative Institute for Limnology and Ecosystems Research, 4840 South State Rd., Ann Arbor, MI, 48408; [4]School of Natural Resources and Environment, University of Michigan, 440 Church St., Ann Arbor, MI, 48109; [5]US EPA Great Lakes National Program Office, 77 W. Jackson Blvd, Chicago, IL, 60604. **A Comparison Of Recent Changes In Nutrients And The Lower Food Web In Lake Huron And Lake Michigan.**

In recent years the lower food webs of both Lake Huron and Lake Michigan have experienced substantial changes, including dramatic reductions in the size of the spring bloom, increases in water clarity and declines in spring total phosphorus concentrations, declines in *Diporeia* populations, and a shift in summer crustacean communities away from cladocerans towards calanoid copepods. While some of these changes have occurred in parallel, in other

cases important distinctions have been apparent in both their timing and magnitude. For example, shifts in crustacean communities have been more sudden and pronounced in Lake Huron, but have not resulted in the absolute increases in biomass of the glacial relict species *Limnocalanus macrurus* as have been seen in Lake Michigan. Thus it is not clear if the same causal mechanisms are at work in the two lakes. Here we'll compare the trajectories of nutrient and lower food web changes in lakes Michigan and Huron, particularly in the context of potential causal mechanisms, in an attempt to determine the extent to which the two lakes may or may not be responding to similar drivers. *Keywords: Phosphorus, Zooplankton, Nutrients.*

BARCLAY, P., BASTONI, C., EISENHAUER, D.E., HASSAN, M., LOPEZ, M., MEKIAS, L., RAMACHANDRAN, S., and STOCK, R., University of Michigan School of Natural Resources, 440 Church St, Ann Arbor, MI, 48109. **Adaptive Synergies: Mainstreaming Resiliency in Great Lakes Cities.**

Can the cities of the Great Lakes region adapt to climate change while remaining or becoming more economically, socially, or ecologically resilient? Answering this question requires understanding how social, economic, political and ecological processes interact over various scales to shape climate adaptation. The most accurate climate models predict even warmer temperatures and shifting precipitation patterns with an increased likelihood of extreme events by the end of the 21st century. To further understand how the Great Lakes region can adapt to the climatic changes predicted, we conducted an Integrated Assessment of four Ohio cities (Avon Lake, Dayton, Elyria, and Toledo) and measured their adaptive capacity. With this measurement, we can provide policy recommendations and best practices to better cope with the potential impacts of climate change. Between the four cities, sixty interviews with decision makers were conducted. Using qualitative coding software this data was analyzed to identify leverage points, synergistic projects and collaborations. We have successfully identified constraints to adaptations as well as political instruments and additional resources that will decrease vulnerability. We hope that this study will help establish a network within the cities that will favorably address the threat of climate change. *Keywords: Assessments, Adaptive capacity, Climate change, Mitigation, Decision making.*

BARKER, J.E.[1], KELLY, J.R.[2], SCHAROLD, J.V.[2], CORRY, T.D.[2], and YURISTA, P.M.[2], [1]ORISE Fellow, U.S. EPA, Duluth; [2]U.S. EPA Mid-Continent Ecology Division, 6201 Congdon Blvd., Duluth, MN, 55804. **Using Underwater Video Imaging as an Assessment Tool for Coastal Condition.**

As part of the National Coastal Condition Assessment (NCCA) to monitor ecological conditions in nearshore habitats, underwater videos were captured at over 400 locations throughout the Laurentian Great Lakes from 2009-2012. This study focuses on developing a video rating system and assessing video images. This rating system provides a standard method to remove videos from analysis that are indistinct and unusable, or whose poor quality may introduce subjective bias. Correlation of video rating with water quality parameters measured on site is being used to develop a protocol to determine environmental limits for video sampling. To

date, all images have been rated and examined for substrate type, vegetation presence and type, fish presence and type, and dreissenid mussel presence. Mussel presence detected in videos is currently being compared with site paired sediment grab data to determine the ability of both gear types in dreissenid detection. Preliminary analyses encourage us that, through our structured evaluation process, we will be able to identify the limits for use of this tool as well as the overall confidence in it as a rapid assessment method for future NCCA surveys. *Keywords: Coastal ecosystems, Monitoring, Ecosystem health.*

BARNES, M.A., DEINES, A.M., GENTILE, R.M., and GRIENEISEN, L.E., Department of Biological Sciences, University of Notre Dame, Notre Dame, IN, 46556. **Adapting to biological invasions through harvest: what can we learn from existing "experiments?".**

Interest in harvest as an invasive species management strategy has recently surged. Researchers speculate about potential positive (population and impact reduction, economic losses recouped through new profits) and negative (generation of economic incentives to encourage further introductions) consequences of such management strategies, but few formal analyses exist despite the growing number of real-world "experiments." A useful first step to understanding the implications of invasive species harvest is to document such ongoing efforts. We have assembled the first comprehensive list of the many ways humankind has adapted to the presence of invasive species through harvest, and several lessons emerge from this list. Harvested invaders serve a variety of purposes ranging from biofuels to foods. The spectrum of harvest types range from collection of feral populations to deliberate cultivation of potential invaders. We caution that the costs of invasion and benefit from harvest can be difficult to quantify, and this difficulty is compounded by the fact that costs and benefits are often incurred by different stakeholders. We conclude that ecologists, economists, managers, and other stakeholders must work together to ensure successful and responsible application of ongoing harvests and inform future efforts. *Keywords: Policy making, Harvest, Invasive species, Management.*

BARRETT, C.H.[1], ANTUNES, P.M.C.[2], MCCHRISTIE, M.R.[3], and CHAMBERS, M.J.[4], [1]Algoma University, 1520 Queen St. E., Sault Ste. Marie, ON, P6A 2G4; [2]AquaTox. Testing & Consulting/Algoma University, Sault Sainte Marie, ON, P6A 2G4, [3]Ontario Ministry of the Environment, Thunder Bay, ON, P7E 6S7; [4]Environment Canada, Toronto, ON, M3H 5T4.
Binational Multi-stakeholder Cooperation and Engagement in the Decision Making Process and Remedial Actions for the St. Marys River Area of Concern.

The St. Marys River connects Lake Superior and Lake Huron and is often referred to as the "Hub of the Great Lakes." Since the early 1900s the river and surrounding area has been impacted by industrial and municipal operations. As a result of the adverse environmental effects caused by industrialization, the St. Marys River was designated as an Area of Concern under Annex 2 of the 1987 Canada-US Great Lakes Water Quality Agreement. The subsequent development of a Remedial Action Plan (RAP) and environmental impact assessment, found 9 of the 14 Beneficial Use Impairment (BUI) categories to be 'impaired.' Public participatory action and multi-stakeholder engagement has played a critical role in implementing the RAP for the St. Marys River. Since its inception in 1988, local government agencies, non-government organizations, and private citizens have helped guide the initial assessment of BUIs. More recently, these groups have been helping to define the restoration targets upon which each BUI will be assessed. Our presentation will highlight the framework used to facilitate the engagement of many stakeholders, and will also provide an overview of these voluntary collaborations by Canada, US, and Aboriginal communities throughout the RAP process. *Keywords: Public participation, Remedial Action Plan, Outreach, Binational cooperation, Remediation, Stakeholder engagement.*

BARTH, L.E.[1], SPRULES, W.G.[2], and SURUGIU, A.[2], [1]27 King's College Circle, Toronto, ON, M5S 1A1; [2]3359 Mississauga Road North, Mississauga, ON, L5L 1C6. **Wind-Induced Water Movement Causes Patterns in Zooplankton Spatial Distribution.**

The direct forcing of wind causes water masses at different depths to move in different directions and speeds. Consequently, zooplankton entrained within these water masses should be moved to different areas of a lake. We predict that zooplankton species would be moved at speeds and directions commensurate with the depth strata that they occupy. To test this we tracked the movement of water masses at three depths of Lake Opeongo, Ontario (surface, middle and bottom of the epilimnion) using GPS-equipped drogues while simultaneously profiling the depth distribution of zooplankton species in the water masses. Drogues were released in the morning near two fixed locations (6 km apart) at the Western and Eastern portion of the basin corresponding to upwind and downwind sites. Zooplankton pump samples and vertical temperature profiles were collected in the morning when the drifters were released and in the afternoon when the drifters were picked up. The sample protocol included collecting zooplankton samples from the same three depths the drifters were set at the two fixed locations. This procedure was repeated during four four-day long sample periods from June to September 2012. We will present an analysis of the relationship between water mass movement and the size and species composition of zooplankton at depth. *Keywords: Water currents, Zooplankton, Spatial distribution.*

BARTOLAI, A.M.[1], HE, L.[2], and HURST, A.E.[3], [1]University of Minnesota-Twin Cities, Minneapolis, MN; [2]University of Michigan, Ann Arbor, MI; [3]McGill University, Montreal, QC. **An Examination of Climate Change in the Great Lakes - St. Lawrence River Basin and Envisioned Scenarios for Future Adaptation and Mitigation.**

Climate change in the Great Lakes -St. Lawrence River Basin (GLB) is affecting crucial processes in the ecological system, as well as 48.5 million residents who depend on the Lakes for drinking water, energy, and industries. Over the past 50 years, the GLB has experienced increased air temperatures and heavier precipitation events. The extent of future changes will vary seasonally and regionally, with greater change occurring in winter and spring. Climate change is interconnected with many other drivers of change in the Basin. Policies and industry are driving emissions of greenhouse gases and carbon sequestration; while the ecological and economic impacts of climate change will manifest themselves through changes in lake water quantity, biological and chemical contaminants and invasive species. Future energy and governmental policy along with changes in demography and societal values will have significant impacts. This paper investigates the historical and future trends of the climate and emphasizes its interaction with these drivers. The paper concludes by offering three plausible future scenarios of mitigation and adaptation plans to climate change, suggesting that it is urgent to have extensive collaborations of scientists and policy makers, to develop a balance between ecological and economic systems. *Keywords: Great Lakes basin, Adaptation, Climate change, Scenarios, Mitigation.*

BASKARAN, M.[1] and BRATTON, J.F.[2], [1]Department of Geology, Wayne State University, Detroit, MI, 48202; [2]Great Lakes Environmental Research Laboratory, National Oceanic and Atmsopheric Administration, Ann Arbor, MI, 48108. **Report on the Workshop entitled "Recent Changes in the Biogeochemistry of the Great Lakes System" held on 11-13 March, 2013 at Wayne State University, Detroit, MI.**

A National Workshop was held at Wayne State University - Detroit during March 11-13, 2013 to assess scientific research needs to address major biogeochemical changes that have been taken place over the past five decades in the Great Lakes ecosystem. There have been several major biogeochemical alterations in the Great Lakes system due to a number of factors that include: i) introduction of invasive species since the mid 1980s; ii) abatement of P loading; and iii) climate change that impacts the water cycle, runoff, thermal structure, and ice cover with significant consequences for the micro- and macro-nutrient loading and cycling. These changes have resulted in the alterations of pelagic and benthic food webs and associated elemental cycles. In the near-shore areas of Lakes Huron, Erie, and Ontario, significant decreases in the concentrations of P, phytoplankton, and chlorophyll and Chl-a/P ratios coincided with the establishment of dreissenid zebra mussels and later quagga mussels. These and numerous other changes such as decreased pelagic productivity and lower amounts of OC in benthic sediments have been driven by alterations in the sources, pathways and cycling of nutrients in the littoral regions of the Great Lakes system. In our presentation, we will summarize major outcome of this proposed workshop. *Keywords: Stable and radioactive isotopes, Geochemistry, Nutrient dynamics, Biogeochemistry, Environmental effects.*

BAUGHMAN, A.E. and STREET, G.L., 325 E. Lake Street, Petoskey, MI, 49770. **A Challenge: How to Remediate the Largest TCE Plume in the U.S.**

One of the country's largest plumes of trichloroethylene (TCE) contamination (5.4 miles and over 4,000 acres) has contaminated drinking water wells in a rural, low-income community in northern Michigan. The aquifer is estimated at 13 trillion gallons. Because there are no responsible parties, the State of Michigan has taken responsibility. Michigan DEQ believe it is not cost effective to pump and treat the TCE, and has supported the development of a municipal water and sewer system. The State has invested approximately $17 million on monitoring and well construction. To date, there have been no investments or actions taken to contain or clean up

the plume. Freshwater Future is organizing a collaborative effort involving faculty and students from universities in the Great Lakes region, retired environmental scientists and engineers, and local community leaders. The desired outcome will include: • A long-term solution that utilizes the most appropriate technologies to curtail the advance of the TCE plume and ensure safe drinking water for residents. • Collaborative problem solving with extensive community engagement. • Buy in of the results by the community . • A work product that can be used as a model for addressing other TCE sites. There are several hundred within the U.S.
Keywords: Organochlorine compounds, Trichloroethylene (TCE), Pollution sources, Ground Water, Lake Michigan.

BAUSTIAN, J.J., KOWALSKI, K.P., and CZAYKA, A., USGS Great Lakes Science Center, 1451 Green Rd, Ann Arbor, MI, 48105. **Restoring Hydrologic Connectivity in Lake Erie Coastal Marshes to Improve Water Quality.**

In the Great Lakes basin, coastal wetlands often are geographically situated to intercept nutrients and sediments coming off the landscape before they reach the Lakes. Unfortunately, most coastal wetland habitat has been degraded or lost through conversion to agriculture, urbanization, or hydrologic alteration, including isolation with earthen dikes. Diked wetlands are disconnected hydrologically from their parent water body, limiting the exchange of water and the potential to act as nutrient and sediment sinks. Reconnecting diked wetlands to their parent water body can rehabilitate critical habitats and increase nutrient and sediment retention capacity. Ongoing wetland research in western Lake Erie has produced an innovative approach to estimate phosphorus and sediment retention in a reconnected diked marsh. By coupling real-time measurements of discharge and turbidity, we developed an empirical model predicting total P and suspended sediment concentrations from turbidity measurements. Data were coupled with discharge data to estimate nutrient flux through time. We found that the reconnected wetland was a sink for P and sediment throughout the year, although temporal variability was observed. Early results indicate reconnecting coastal wetlands has the potential to improve water quality as well as fish and wildlife habitat. *Keywords: Phosphorus, Water quality, Nutrients.*

BEACHLER, D.[1], FENELON, E.[1], LENNING, E.[1], CASTRO, R.[1], ROCKWELL, D.[2], and CAMPBELL, K.[2], [1]Chicago National Weather Service Forecast Office, 333 West University Drive, Romeoville, IL, 60446; [2]CILER University of Michigan and NOAA Center of Excellence for Great Lakes and Human Health,GLERL, 4840 South State Road, Ann Arbor, MI, 48108.
2013 NOAA Beach Water Quality Experimental Forecasting for Five Chicago Park District Beaches.

NOAA has extended the Beach Water Quality Experimental Forecasting Initiative in 2013 to include five beaches from Chicago Park District Lake Michigan. These beaches meet key criteria including 100 or more E. coli samples, hydrodynamic lake data, Swimcast decision support system availability, and 5% or more historical E. coli samples exceeding the state single sample regulatory standard. US EPA's Virtual Beach 2.3 is used to develop a beach forecasting decision support system for each beach. This talk will present the National Weather Service

Forecast Office operational issues in making available 48 hour forecasts for Calumet, Foster, Jackson 63rd Street, Montrose, and Oak Street beaches. *Keywords: Decision making, Water quality, Ecosystem forecasting.*

BECHLE, A.J. and WU, C.H., 1415 Engineering Drive, Madison, WI, 53706. **Meteorological Tsunamis in the Great Lakes.**

Meteotsunamis (or meteorological tsunamis), are propagating water waves generated by a moving atmospheric disturbance. Meteotsunamis exhibit many similarities with seismic tsunamis, as both have wave periods of 2 minutes to 2 hours and undergo resonant amplification that transforms relatively small waves in the open water into destructive forces at the coast. In the Great Lakes, there have been several incidents of meteotsunamis. The most vivid event occurred in 1954, when a 3 meter wave struck Chicago with 7 people reported dead. In this talk, the frequency of meteotsunami occurrences from the last decade in the Great Lakes will be reported. Atmospheric records from the network of observation stations in the Great Lakes region, along with radar and satellite imagery, will be utilized to characterize the meteorological conditions that accompany these meteotsunami events. Furthermore, a sensitivity study using a hydrodynamic model of Lake Michigan will be performed to determine the "worst case" conditions for meteotsunami formation and identify the locations in the lake most likely to experience large meteotsunamis. The results of this study will help mitigate the risk associated with these destructive waves. *Keywords: Waves, Water level fluctuations.*

BEECRAFT, L.[1], SMITH, R.E.H.[1], and WATSON, S.B.[2], [1]University of Waterloo, 200 University Ave West, Waterloo, ON, N2L 3G1; [2]National Water Research Institute, 867 Lakeshore Rd, Burlington, ON, L7R 4A6. **Multi-wavelength Spectrally Resolved Fluorometric Assessment (Phyto-PAM) of Photosynthetic Sensitivity to Solar Radiation Stress in Major Phytoplankton Groups.**

Solar radiation stress is an important but poorly quantified influence on phytoplankton species dynamics. Different taxa are known to exhibit varying sunlight stress tolerance, but techniques are lacking to assess sensitivity and its implications for natural system dynamics. Variable chlorophyll a fluorescence can provide rapid measures of photosynthetic efficiency, and the spectral fluorometer PhytoPAM breaks down the fluorescence signals to distinguish three major groups of phytoplankton: blue-greens, greens, and browns. Acute exposure experiments to different portions of the solar spectrum were performed on representative species from each group and changes in photosynthetic efficiency were measured via pulse-amplitude modulated fluorometry. Photoinhibition manifests as reduced photosynthetic yield following supra-optimal irradiance exposure. Stressed responses resulted from UV exposure, with full spectrum treatments producing decreased yields: 50-75% in blue-greens, 45% in diatom species, and 15% in green species. Responses were modeled to compare taxa and give estimated rates of damage and repair; however, relative responses between taxa did not follow the expected pattern. Further experiments on mixed samples compare stress responses and discrimination capabilities of the PhytoPAM fluorometer. *Keywords: Phytoplankton, Monitoring, Ultraviolet radiation.*

BEHUM, M.[1], PREZIOSI, D.[1], and PASTOROK, R.[2], [1]Integral Consulting Inc., 200 Harry S. Truman Parkway, Suite 300, Annapolis, MD, 21401; [2]Integral Consulting Inc., 411 1st Avenue S, Suite 550, Seattle, WA, 98104. **Ecological Relevance of Great Lakes Chemicals of Emerging Concern - Part 1, The Role of Risk Assessment.**

A fundamental paradigm shift is currently needed to move beyond screening and listing of emerging chemicals of concern so that more meaningful insight can be gained on potential ecological impacts these chemicals may pose to aquatic populations and the wildlife that depend on them in the Great Lakes basin. Under Annex 12 of the Great Lakes Water Quality Agreement, attention has been placed on screening chemicals and generating chemical listings. At their core, the screenings rely on basic characteristics related to chemical hazard and the ability to monitor substances in the environment. While such methods may be appropriate for initial screening, additional effort is needed to determine the ecological relevance of listed chemicals in terms of their potential ecological risk in the Great Lakes ecosystem. In this first of two talks, we present a framework to identify, organize and synthesize information needed to appropriately characterize potential ecological impacts to selected chemicals of emerging concern in the Great Lakes. Consistent with the USEPA paradigm for ecological risk assessment, the framework uses information relevant to potential chemical associated effects (i.e., chemical ecotoxicity and environmental fate) alongside information relevant to characterizing ecological exposure.
Keywords: Risk assessment, Environmental contaminants, Ecosystems.

BELETSKY, D.[1], HU, H.[1], WANG, J.[2], and HAWLEY, N.[2], [1]University of Michigan, Ann Arbor; [2]NOAA Great Lakes Research Laboratory, Ann Arbor. **Modeling winter circulation and ice in Lake Erie.**

Winter circulation and thermal structure in Lake Erie is studied with a three-dimensional coupled Great Lakes Ice-circulation Model (GLIM) during 1979-1980 and 2010-2011. The hydrodynamic model has 20 vertical levels and a uniform horizontal grid size of 2 km. The model uses time-dependent wind stress and heat flux forcing at the surface which are calculated from the hourly meteorological observations obtained from National Weather Service land stations and NOAA buoys. The model reproduces several month long ice periods in both winters with maximum ice thicknesses up to 45 cm in 1979-1980. The model is validated with hourly temperature and current measurements at several moorings that were deployed in central basin of Lake Erie during both winters and additionally with ice concentration and thickness measurements in 2010-2011. *Keywords: Lake Erie, Hydrodynamics, Ice.*

BELETSKY, R.[1], BELETSKY, D.[1], and HAWLEY, N.[2], [1]University of Michigan, Ann Arbor; [2]NOAA Great Lakes Research Laboratory, Ann Arbor. **Modeling circulation and residence time of Saginaw Bay.**

A 3-dimensional hydrodynamic model and a particle transport model are used to study circulation and thermal structure in Lake Huron, and water residence time in Saginaw Bay in 1991-1996 and 2008-2010. Model results show significant seasonal and interannual variability in

circulation patterns and water exchange between Saginaw Bay and Lake Huron. Hydrodynamic model results are tested with observations of water level, currents and temperature. Particle transport model results indicate water residence times longer than previously reported. *Keywords: Hydrodynamic model, Lake Huron.*

BELISLE, B.S.[1], STEFFEN, M.M.[1], POUND, H.L.[1], BOYER, G.L.[2], WATSON, S.B.[3], BOURBONNIERE, R.A.[4], and WILHELM, S.W.[1], [1]University of Tennessee, Department of Microbiology, Knoxville, TN, 37996; [2]State University of New York, New York, NY, 13210; [3]Enviornment Canada, Canada Centre for Inland Waters, Burlington, ON, PO Box 5050, Canada; [4]Environment Candada, National Water Research Institute, Burlington, ON, L7R 4A6.
Is Urea a Driver for *Microcystis* Blooms in Lake Erie?

Microcystis aeruginosa is a cyanobacterium that grows colonially in freshwater systems around the world. Microcystis can proliferate to form dense blooms that lead to large-scale deterioration of aquatic habitats and potential serious public health issues. Subpopulations of these cyanobacteria can produce multiple toxins, including microcystin, a potent hepatotoxin. These blooms occur in the greatest density in waters affected by eutrophication. Agricultural runoff is often responsible for an influx of nutrients, such as nitrogen and phosphorus, which have been shown previously to play important roles in bloom proliferation. Urea is an organic form of nitrogen frequently used as fertilizer, resulting in urea being a common nitrogen load to freshwater environments. Multiple cyanobacteria, including Microcystis spp., possess the urease enzyme, which hydrolyzes urea into ammonia and carbon dioxide. To identify the potential role of urea in driving blooms of Microcystis in Lake Erie, urease enzymatic activity was measured at multiple stations in the lake using the indophenol method. Preliminary field and laboratory data suggest up-regulation of the urease enzyme activity in cultures and field samples of Microcystis spp. In combination with growth assays, our data suggest that urea may be an under-appreciated driver of bloom events. *Keywords: Harmful algal blooms, Urease Activity, Lake Erie, Chlorophyll a Concentrations, Microcystis.*

BELNAP, M.J.[1], ISERMANN, D.A.[2], SLOSS, B.L.[2], and VANDEHEY, J.A.[3], [1]Wisconsin Cooperative Fishery Research Unit, 800 Reserve St, Stevens Point, Wi, 54481, United States; [2]U.S. Geological Survey, 800 Reserve St, Stevens Point, WI, 54481; [3]Wisconsin Cooperative Fishery Research Unit, Fisheries Propagation Science Center, 800 Reserve St, Stevens Point, WI, 54481. **Stock Characteristics of Lake Whitefish in Lake Michigan.**

Lake whitefish *Coregonus clupeaformis* support important recreational, commercial, and tribal fisheries in the Great Lakes, including Lake Michigan. Genetic analyses indicate at least six distinct lake whitefish stocks exist in Lake Michigan resulting in a mixed-stock fishery. Biological characteristics could vary among these stocks, which could result in stock-specific responses to exploitation. The objectives of our study were to determine if capture location in October is an accurate identifier of genetic stock and to determine if stocks differ in terms of growth, maturation, age structure, condition, and fecundity. Initial results indicate that some biological differences exist among stocks; continued analysis will determine if these differences are meaningful from a management standpoint. *Keywords: Genetics, Lake Michigan, Fish management.*

BENCE, J.R.[1], BRENDEN, T.O.[1], and JOHNSON, J.E.[2], [1]Department of Fisheries and Wildlife, Michigan State University, East Lansing, MI, 48824; [2]Alpena Fisheries Research Station, 160 E. Fletcher, Alpena, MI, 49707. **Sensititivity of Chinook Salmon Stock Assessment in Lake Huron to Assumed Wild Recruitment.**

Chinook salmon had become an important predator in the main basin of Lake Huron during the 1960s and 1970s as a consequence of large-scale hatchery plantings. Subsequently, naturalized runs became established and contributed substantially to the population. We developed an age-structured stock assessment model and estimated recruitment, abundance, and mortality over time. This tracks the increase to prominence and collapse of the fishery in more recent years. Here we update that model and evaluate the sensitivity of that assessment model to assumed levels of recruitment during the 1990s, a period during which wild recruitment increased but for which there is little data. We focus on how assumed levels of recruitment influence the estimated timing of the decline in the Lake Huron main basin Chinook salmon population. *Keywords: Fish, Fish populations, Lake Huron.*

BERGES, J.A., GRONQUIST, D.J., ENGEVOLD, P.M., and SANDGREN, C.D., Dept. Biological Sciences, U. Wisconsin-Milwaukee, 3209 N. Maryland Ave., Milwaukee, WI, 53211. **Immunochemical Approaches to Determine Diet of an Invasive, Zooplankton Predator in Lake Michigan.**

The Ponto-Caspian invader *Bythotrephes longimanus* became established in Lake Michigan by 1986 and is abundant in warmer surface waters in summer/autumn. Determining the effects of this carnivorous cladoceran is complicated by the fact that they selectively ingest soft tissues, making assessments of prey preference through analysis of gut contents impossible. From 2007 through 2009, alongside field surveys and laboratory grazing studies, we developed polyclonal antisera to 7 species of putative prey (including copepods, rotifers, herbivorous cladocerans, and veliger larvae) and subtractively cross-purified them. In all cases, antisera raised in rabbits were of high titer, effectively allowing detection of prey protein in guts of single predators. Evidence that *B. longimanus* guts contain dressenid veligers and large carnivorous copepods, suggest that revisions of previous ideas of food web interactions may be needed. *Keywords: Lake Michigan, Bythotrephes, Food chains, Imunochemistry, Zooplankton.*

BERNINGER, J.P.[1], ANKLEY, G.T.[1], CAVALLIN, J.E.[1], DURHAN, E.J.[1], EID, E.[1], JENSEN, K.M.[1], KAHL, M.D.[1], LALONE, C.A.[1], MAKYNEN, E.A.[1], SEVERSON, M.N.[1], STEVENS, K.E.[1], VILLENEUVE, D.L.[1], COLLETTE, T.W.[2], EKMAN, D.R.[2], PERKINS, E.J.[3], and GARCIA-REYERO, N.[4], [1]US EPA - MED, 6201 Congdon Blvd, Duluth, MN, 55802; [2]US EPA - ERD, Athens, GA; [3]US Army - ERDC, Vicksburg, MS; [4]Mississippi State University, Starkville, MS. **Novel Effects-based Monitoring Approaches to Evaluate Chemicals of Emerging Concern in Great Lakes Areas of Concern.**

As part of an on-going program of research in support of the Great Lakes Restoration Initiative, we have been developing effects-based biomonitoring tools to evaluate the occurrence and potential hazards associated with Chemicals of Emerging Concern (CECs). Over three years caged fathead minnows were deployed at multiple sites within several GL Areas of Concern, particularly near waste water treatment discharges. Grab and/or composite samples of surface water were collected concurrent with fish exposures and used for chemical analysis of target CECs and in vitro bioassays. Following field exposures, fish were sampled and tissues analyzed using targeted methods relevant to reproductive and endocrine functions as well as more open-ended methods including transcriptomics and metabolomics. Estrogenic activity was detected in a number of surface water samples collected. Impacts on circulating concentrations of steroid hormones, as well as expression of xenobiotic metabolizing enzymes in liver were also detected. Vitellogenin, a biomarker of estrogen exposure in male fish, was only significantly elevated at one site. The experiments to date have evaluated a range of locations and exposure scenarios. Ongoing efforts will focus on the impacts of changes in municipal discharges over time on biological response profiles in caged fish. *Keywords: Environmental effects, Environmental contaminants, Endocrine disruption.*

BIBERHOFER, C.R. and CHOW-FRASER, P., 1280 Main Street West, Hamilton, ON, L8S 4L8. **How is GCC affecting habitat quality and quantity of Northern pike in eastern Georgian Bay?**

Decreased water levels in the Great Lakes induced by Global Climate Change (GCC) have the potential to negatively alter fish habitat quantity and quality. With water-level declines and increasing water temperatures, suitable fish habitat may be lost, in an interactive or additive manner. Georgian Bay, Lake Huron has experienced over a decade of water level decline, and the effects on keystone species such as northern pike (*Esox lucius*) are not yet known. We created a 3-dimensional model of thermal habitat focusing on the literature-based optima for growth as optimal habitat for northern pike in Tadenac Bay, a pristine embayment in eastern Georgian Bay. This model was validated with location data of 12 radio-tracked northern pike, collected periodically from May 2011 to November 2012. Our data indicate that northern pike used wetland habitat that is warmer than the optima and frequently >27°C. Laboratory-based literature suggests that at 28°C, northern pike will cease to feed. The ramifications of remaining in thermally unsuitable water for significant amounts of time include stunted growth and potential death. The potential for greater negative effects from GCC necessitates further study of habitat use by pike in water that is not thermally optimum for growth. *Keywords: Northern pike, Temperature, Georgian Bay.*

BICKFORD, W.A.[1], KOWALSKI, K.P.[1], GALBRAITH, D.M.[2], and EGGLESTON, M.R.[1], [1]USGS Great Lakes Science Center, 1451 Green Rd, Ann Arbor, MI, 48105; [2]USFWS R2 Inventory and Monitoring, 500 Gold Ave. SW, Albuquerque, NM, 87102. **Invasive Phragmites in Great Lakes coastal corridors: combining radar mapping and a habitat suitability modeling in an online decision support tool.**

The non-native strain of Phragmites australis (common reed) spreading through the Great Lakes basin is having great ecological, economic, and social impact. The Great Lakes Restoration Initiative provided funding to develop a basin-wide map of current Phragmites distribution, an invasion vulnerability assessment, and a decision support tool that will allow managers to prioritize control efforts, develop restoration strategies, and aid in the early detection. Our modeling efforts analyzed the relationships between the current Phragmites distribution and landscape-level environmental variables in the Great Lakes coastal zone. Statistical approaches to ecological niche modeling were used to develop a habitat suitability index based on the environmental drivers of existing Phragmites distribution. Elevation data allowed the simulation of corridors during reduced lake level scenarios, and calculations of the distance to existing Phragmites led to a proximity index. These two indices were used to forecast vulnerability to future Phragmites invasion in the coastal zone. An online map-based decision support tool (http://cida.usgs.gov/glri/phragmites/) hosted by the USGS allows custom depictions of the distribution maps and vulnerability assessment at user-defined scales. *Keywords: Coastal wetlands, Phragmites, Invasive species, Lake Erie.*

BIDWELL, D.C., 625 E. Liberty St., Suite 300, Ann Arbor, MI, 48104. **GLISA: Co-Production of Climate Information.**

The Great Lakes Integrated Sciences and Assessments Center (GLISA) is a collaboration of the University of Michigan and Michigan State University. GLISA is one of the National Oceanographic and Atmospheric Administration's eleven Regional Integrated Science and Assessments (RISAs), which build the capacity of decision makers to cope with climate variability and change. A central feature of RISAs, and of GLISA specifically, is the co-production of useable climate information. In this session, GLISA will review its projects that directly engage local and sectoral experts in research and the translation of climate data. *Keywords: Climate change, Climatic data, Public participation.*

BIK, H.M., UC Davis Genome Center, Davis, CA, 95616. **Biodiversity and the (data) beast: computational challenges for ecogenomic monitoring of microbial eukaryotes.**

Microbial eukaryotes (e.g. nematodes, fungi, protists, and other 'minor' metazoan phyla) are diverse and abundant in every habitat on earth, yet for most groups we possess scant knowledge of species distributions and global diversity. Meiofaunal taxa often show rapid response to disturbance, and have been touted as ideal organisms for tracking environmental impacts. However, underdeveloped bioinformatic pipelines and the lack of reference genomes have severely hindered the utility of ecogenomic approaches for these taxa. To date, high-throughput studies of environmental diversity (454, Illumina) have been limited in scope, relying heavily on ribosomal marker genes (18S rRNA). Here we present recent efforts towards tackling the perpetual computational bottlenecks associated with the study of microbial eukaryotes in large sequence datasets. Improving tools for eukaryotic metagenome analysis will be imperative for building a robust picture of ecosystem function; incorporating shotgun environmental data will ultimately assist in surmounting the significant informatic challenges faced in interpreting eukaryotic rRNA datasets (e.g. stemming from the existence of intragenomic variation across rRNA genes in eukaryotic genomes). *Keywords: Biomonitoring, Genomics, Biodiversity, Eukaryotes, Genetics, Nematodes.*

BLAIR, B.D.[1], CRAGO, J.P.[1], HEDMAN, C.J.[2], and KLAPER, R.D.[1], [1]School of Freshwater Sciences, University of Wisconsin - Milwaukee, 600 E Greenfield Ave, Milwaukee, WI, 53202, United States; [2]State Laboratory of Hygiene, University of Wisconsin-Madison, 2601 Agriculture Drive, Madison, WI, 53718. **Occurrence of Fifty-four Pharmaceuticals and Personal Care Products in a Wastewater Treatment Plant and in Lake Michigan.**

The monitoring of pharmaceuticals and personal care products (PPCPs) has focused on the distribution in rivers and small lakes, but data regarding their occurrence in large lake systems, such as the Great Lakes, are sparse. Wastewater treatment processes have not been optimized to remove influent PPCPs and this is a major source of PPCPs in the environment. The purpose of our experiment was to evaluate the concentration, and corresponding risk, of PPCPs in final wastewater effluent and in Lake Michigan. Fifty-four PPCPs and hormones were assessed in water and sediment on six different dates over a two-year period from South Shore Water Reclamation Facility in Oak Creek, WI. Surface water and sediment samples were collected up to two miles from shore and at two sites within the Milwaukee Harbor. Thirty-eight PPCPs were detected in water and thirty were detected in the sediment, with numerous PPCPs being detected up to two miles away from the shoreline. To determine the ecological risk, the environmental concentrations were compared to the predicted no-effect concentration. The widespread detection of PPCPs in Lake Michigan demonstrates the ubiquitous presence of these pollutants in the Great Lakes and many PPCPs were found to be of high ecological risk. *Keywords: Environmental contaminants, PPCPs, Lake Michigan, Risk assessment.*

BLAZER, V.S.[1], WALSH, H.[2], BRAHAM, R.[2], HAHN, C.M.[2], SPERRY, A.[2], and IWANOWICZ, L.R.[1], [1]U.S. Geological Survey, Fish Health Branch, Leetown Science Center, 11649 Leetown Road, Kearneysville, WV, 25430; [2]Cooperative Fish and Wildlfe Unit, West Virginia University, Morgantown, WV, 26506. **Fish Health Endpoints as Indicators of Environmental Health at Areas of Concern: Considerations and Findings.**

Historically, legacy contaminants including PCBs, PAHs, organochlorine pesticides and metals, have been the major concerns at Great Lakes Areas of Concern. However, more recently newer classes of chemicals, current-use pesticides, hormones, organic wastewater compounds and others have been recognized as potentially contributing to adverse effects. In the environment organisms are exposed to complex mixtures of legacy and chemicals of emerging concern, compounds such as phytosterols, phytoestrogens and algal toxins, as well as pathogens and parasites. While chemical analyses are a snapshot in time, organisms integrate the responses to stressors throughout their lifespan. To understand the cumulative impacts of these stressors, a suite of biological responses from organism (necropsy-based, morphometric) to cellular/subcellular (microscopic pathology and plasma analyses) to molecular changes were measured in four species of fish. To complement wild fish responses and chemical analyses, cell-based receptor analyses (estrogen, androgen, glucocorticoid) were also conducted on extracts of discrete water samples. Site and species differences will be discussed. Findings emphasize the complexities in identifying causes and predisposing factors for responses such as neoplasia and endocrine disruption. *Keywords: Bioindicators, Endocrine disruption, Fish.*

BLUME, L.J.[1], PALMER, C.J.[2], STAPANIAN, M.A.[3], and AMOS, M.M.[2], [1]U.S. EPA Great Lakes National Program Office, 77 West Jackson Boulevard, Chicago, IL, 60622; [2]CSC, 6101 Stevenson Avenue, Alexandria, VA, 22304; [3]US Geological Survey, 100 Columbus Avenue, Sandusky, OH, 44870. **Interagency Quality Assurance Guidance for Habitat Restoration Projects.**

Over the past several years, GLRI funding has supported hundreds of projects to undertake habitat restoration & invasive species control projects in the Great Lakes region. Each of these projects relies on the collection of reliable environmental data during project planning & implementation, & follow-up monitoring activities. To assist with these efforts, an interagency committee was formed to provide QA guidance to GLRI participants for their data collection efforts. The overall goal was to build upon the expertise and experiences of QA experts from various federal agencies (e.g., EPA, NOAA, NPS, USACE, USGS, USFS) involved in the GLRI. After a review of QA planning activities by GLRI participants, interagency committee members determined that QA guidance was needed in four areas: 1) establishing quality objectives, 2) achieving quality objectives, 3) evaluating data quality, & 4) data management. This presentation will consider how to address these 4 areas as well as exploring the importance of 1) training, certification, and assessments using standard operating procedures for observational ecological measurements; 2) data being assessed against project quality objectives to ensure usability and to identify limitations on use; & 3) data management procedures in place to support data verification & verification activities. *Keywords: Habitats, Invasive species.*

BLUME, L.J.[1], LYNES, C.L.[2], RINGEL, D.M.[2], PETERSON, S.J.[3], AMOS, M.M.[4], and BENJAMIN, E.M.[4], [1]U.S. EPA Great Lakes National Program Office, Chicago; [2]U.S. EPA Region 2, Edison, NJ; [3]ORISE with Region 2, Edison, NJ; [4]CSC, Alexandria, VA. **Using Assessments and Metrics to Improve the Utility of Quality Systems for Achieving Program Outcomes.**

The GLRI is the largest investment in the Great Lakes in 2 decades. USEPA GLNPO's Quality Program responded to this dramatic increase & the associated need for QA planning by performing a multitude of outreach activities. However, now that GLRI is in its fourth year, the focus of quality is spreading from planning into project implementation & assessment. This presentation will discuss the importance of conducting assessments (e.g., site visits, file reviews, laboratory and field audits) & how organizations can use valuable information gleaned from assessments to take corrective action to improve their systems & activities. The presentation also will discuss the development of metrics to assist in measuring accountability & ensuring operations are being conducted in an effective manner. Metrics are currently being drafted to assess approval rates of project planning documents and the implementation of those plans. These metrics maybe used to support senior management & the public in determining the success of the program. A subset of the projects implemented during the first 3 years of the GLRI will be used as a test population for evaluation of these metrics. *Keywords: Assessments.*

BOHLING, M.[1] and LAPORTE, E.[2], [1]15100 Northline Rd, Suite 200, Southgate, MI, 48195; [2]520 E. Liberty St, Suite 310, Ann Arbor, MI, 48101-2210. **Public Outreach of Strategic Habitat Restoration Activities to Address Areas of Concern, Species Diversity and Habitat in the Huron-Erie Corridor.**

The Huron-Erie Corridor once provided spawning habitat for numerous sport and commercial fishes, including lake whitefish, lake sturgeon, walleye and white bass. Changes to the physical habitat, the negative impact of invasive plants and animals and exploitation of native fish species have decreased the ability of the ecosystem to support sustainable fish and wildlife populations and resulted in the designation of five Areas of Concern (AOCs) within the region. A team of scientists and outreach experts are working with local Public Advisory Councils to promote science-based adaptive management approaches to delisting the AOCs. Public education about the Huron-Erie Corridor ecosystem is an important component of habitat restoration projects. Michigan Sea Grant has developed curriculum, public exhibits, videos, diagrams, fact sheets, FLCKR slide collections, websites and conducted public events, developed to communicate the importance of the restoration of native aquatic species and their habitats in the Huron-Erie Corridor. Partners include the Michigan Department of Natural Resources, Huron-Clinton Metropolitan Authority, Environmental Protection Agency, the National Oceanic and Atmospheric Administration, the Southeast Michigan Council of Governments, Ducks Unlimited, local government and others. *Keywords: Invasive species, Habitat restoration, Biodiversity, Areas of Concern, Environmental education.*

BOLES, C.M.W. and FRANKENBERGER, J.R., 225 S. University St., West Lafayette, IN, 47907. **Impacts of Tile Drainage on Streamflow and Water Quality Using the New SWAT Drainage Routines.**

Agricultural subsurface drainage is an important tool in the production of crops in poorly drained soils of the Midwest, and exerts a strong influence on local hydrology and nutrient transport. The Soil and Water Tool (SWAT) has recently provided options for using a new drainage simulation routine that incorporates the Kirkham and Houghoudt drainage equations and a user-defined drainage coefficient, resulting in more realistic simulations of flow and nutrient outputs from tile drains. The new SWAT drainage routines were applied in a 47 km^2 watershed in the St. Joseph River watershed draining to Lake Erie, of which 50% is estimated to be drained. The impact of the new simulation routines and the influence of tile drainage on hydrology and nutrients will be presented. *Keywords: Water quality, Tile drainage, Watersheds, SWAT.*

BONNELL, J.E., BAIRD, A.M., and PROCHASKA, S.C., The Ohio State University, 2021 Coffey Rd, Columbus, OH, 43221. **Barriers and Incentives to Farmer Adoption of Best Management Practices for Reducing Nutrient Runoff.**

Farmers in the Loss Creek Watershed were surveyed and interviewed about their attitudes, awareness, and behaviors related to best practices for nutrient management. Loss Creek is a subwatershed to the Sandusky River watershed - a major contributor of nutrients to the Western Lake Erie Basin where harmful algal blooms have become a high priority issue. The researchers utilized the Social Indicators Planning and Evaluation System to design a survey to analyze farmers' present levels of best practice adoption and obstacles to future adoption. The authors will present results from the survey and follow-up focus group interviews that provide more in-depth information about barriers and incentives to farmer adoption of nutrient management practices to reduce N and P runoff. Preliminary survey results show a relatively high level of awareness about water quality issues, relatively high levels of adoption of best practices, and a high willingness to consider additional practices. This paper will explore how practitioners can address specific farmer barriers and capitalize on incentives to increase farmer adoption of best practices to reduce nutrient runoff from row crop agricultural land.
Keywords: Decision making, Farmer adoption, Water quality, Best management practices, Nutrients.

BOOTSMA, H.A.[1], MOSLEY, C.M.[1], TYNER, E.H.[1], LIAO, Q.[2], and WILCOX, E.M.[1], [1]School of Freshwater Sciences University of Wisconsin-Milwaukee, 600 E. Greenfield Ave., Milwaukee, WI, 53204; [2]Department of Civil Engineering and Mechanics University of Wisconsin-Milwaukee, P.O. Box 784, Milwaukee, WI, 53201. **The Role of Quagga Mussels in Lake Michigan Phosphorus and Carbon Dynamics.**

Since the invasion and spread of quagga mussels (*Dreissena bugensis rostriformis*)in the last decade, significant ecological changes have occurred in Lake Michigan. Due to rapid proliferation and high filtering capacity, quagga mussels act as ecosystem engineers, altering physical habitats and biogeochemical processes. Using laboratory and *in situ* experiments as well as modeling, we show that quagga mussels have a significant influence on phosphorus dynamics and benthic algal production and are an effective carbon sink in Lake Michigan. We used laboratory experiments and *in situ* measurements to parameterize an empirical mussel P excretion model. This model is then used with mussel distribution data to estimate benthic P flux from quagga mussels. The model is also linked to a *Cladophora* growth model to determine how mussel P metabolism may affect *Cladophora* growth under various mixing and temperature scenarios. A similar model was developed to simulate quagga mussel respiration for the nearshore and profundal zones. This model is used to estimate carbon consumption rates for the southern basin of Lake Michigan. Results suggest that almost all of the carbon that sinks to the

bottom of Lake Michigan is intercepted by quagga mussels. *Keywords: Ecosystem modeling, Quagga mussels, Phosphorus, Carbon cycle.*

BOSCH, N.B.[1], BOYER, G.L.[2], CASSELMAN, J.[3], DEPEW, D.[4], DEPINTO, J.V.[5], HOWELL, T.[6], MURRAY, M.W.[7], SCAVIA, D.[8], WATSON, S.B.[9], and WILHELM, S.W.[10], [1]Grace College, Winona Lake, IN; [2]State University of New York-SUNY, Syracuse, NY; [3]Queen's University, Kingston, ON; [4]Queen's University, Kingston, ON; [5]LimnoTech, Ann Arbor, MI; [6]Ontario Ministry of the Environment, Toronto, ON; [7]National Wildlife Federation, Ann Arbor, MI; [8]Graham Environmental Sustainability Institute, Ann Arbor, ON; [9]NWRI - Environment Canada, Burlington, ON; [10]University of Tennessee, Knoxville, TN. **Nutrient Loadings and Algal Bloom, Hypoxia, and Fish Impacts in Lake Erie: Tackling the Climate Component.**

The TAcLE initiative is a major component of the International Joint Commission Lake Erie Ecosystem Priority (LEEP). A major goal of the LEEP initiative is to provide the basis for policy and governance measures aimed to reduce total and dissolved reactive phosphorus loads and resulting impacts, including harmful and nuisance algal blooms (HNABs), hypoxia and resulting impacts to fish, as well as contribute to improved monitoring, governance, and public understanding of the issues. As part of the TAcLE initiative, we present a synopsis of the current state of knowledge on climate change implications for nutrient loads and impacts in Lake Erie, summarizing key processes (e.g., connections between climate, nutrient cycling, hypoxia, HNABs, dreissenids and fisheries), recent data/information on climate and nutrient loading and concentrations, and implications of the information for modeled responses to changes in climate and nutrient loadings. *Keywords: Climate change, Hypoxia, Phosphorus, Harmful algal blooms.*

BOSCH, N.B.[1], EVANS, M.A.[2], SCAVIA, D.[3], and ALLAN, J.D.[2], [1]Environmental Science, Grace College, Winona Lake, IN; [2]School of Natural Resources and Environment, University of Michigan, Ann Arbor, MI; [3]Graham Environmental Sustainability Institute, University of Michigan, Ann Arbor, MI. **Interacting effects of climate change and agricultural BMPs on nutrient runoff.**

Agricultural best management practices (BMPs) have been implemented in the watersheds around Lake Erie to reduce nutrient transfer from terrestrial to aquatic ecosystems and thus protect and improve the water quality of Lake Erie. However, climate change may reduce the effectiveness of these BMPs by altering run-off and other conditions. Using the Soil and Water Assessment Tool (SWAT) we simulated various climate scenarios with a range of BMPs to assess possible changes in water, sediment, and nutrient yields from Lake Erie watersheds. Tributary water flow, sediment yields, and nutrient yields are predicted to increase with sediments increasing the most, indicating a stronger influence of climate on sediment compared to other properties. Our results indicate that agricultural BMPs become more necessary but less effective under future climates; nonetheless, higher BMP implementation rates still can substantially offset those anticipated increases in sediment and nutrient yields. Individual watersheds differ in their responsiveness to future climate scenarios, indicating the importance of targeting specific management strategies for individual watersheds. *Keywords: Watersheds, Nutrients, Ecosystem modeling.*

BOSSENBROEK, J.M.[1], SIERACKI, J.L.[1], and BELETSKY, D.[2], [1]University of Toledo, 2801 W. Bancroft St., Toledo, OH, 43606; [2]NOAA/GLERL, 4840 S. State Rd., Ann Arbor, MI, 48108. **A Multi-model Approach to Identify Possible Locations to Conduct Ballast Water Exchange in the Laurentian Great Lakes.**

Ballast water exchange at sea is an invasive species prevention strategy that has been used by ships entering the Great Lakes. However, this strategy has not been applied within the Laurentian Great Lakes partly due to a lack of known effective exchange locations. In order to prevent the further spread of Eurasian ruffe (*Gymnocephalus cernuus*) and possible future spread of golden mussel (*Limnoperna fortunei*) in Lake Michigan, a 3D hydrodynamic model was used to predict the movement of organisms from known mid-lake ballast discharge locations by lake circulation. We used the results of the hydrodynamic model to identify those locations where the organisms could be discharged without being dispersed to locations where they may establish a population. Further, the hydrodynamic model and a ballast water spread model were used to identify how ruffe and golden mussel may be further spread from the major ports in Lake Michigan, allowing us to identify those ports where it is most important for ships to undertake ballast water exchange prior to entering a port. The model predictions can help identify ballast water discharge locations and "hotspots" in Lake Michigan where it is most crucial to prevent the introduction of Eurasian ruffe and golden mussel. *Keywords: Invasive species, Hydrodynamic modelling, Ballast, Spatial modelling, Risk assessment.*

BOUCKAERT, E.B.[1], AUER, N.A.[1], ROSEMAN, E.F.[2], and BOASE, J.[3], [1]Michigan Technological University, Department of Biology, 1400 Townsend Drive, Houghton, MI, 49931; [2]US Geological Survey, Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105; [3]USFWS Alpena National Fish and Wildlife Conservation Office, Waterford Substation, 7806 Gale Road, Waterford, MI, 48327. **Larval lake sturgeon *Acipenser fulvescens* response near two artificial spawning reefs in the St. Clair-Detroit Rivers System.**

In the St. Clair-Detroit Rivers System (SCDRS), most natural lake sturgeon (*Acipenser fulvescens*) spawning substrate has been eliminated or degraded as a result of channelization and dredging. Efforts are underway to restore spawning substrates by constructing artificial reefs. In 2012, we investigated larval lake sturgeon response to Fighting Island Reef in the Detroit River, and to Middle Channel Reef in the St. Clair River. Near Fighting Island Reef, from 15 May to 4 June, we collected 31 larvae using D-frame drift nets directly downstream of the reef, and only 3 larvae upstream. Larvae had an average total length of 14.9 mm, and 58.8% still had yolk sacs. Near Middle Channel Reef, from 5 to 19 June, we collected 14 larvae in D-frame drift nets downstream of the reef, and 21 larvae upstream. Larvae averaged 19.4 mm TL, and only one had a full yolk sac. Our results indicate that Fighting Island Reef is producing viable lake sturgeon larvae. Near Middle Channel Reef, many larvae may originate from upstream of the reef, suggesting the presence of other natural spawning areas in that system. *Keywords: St. Clair*

River, Larval lake sturgeon, Great Lakes Restoration Initiative (GLRI), Artificial spawning reef, Detroit River.

BOUDREAU, R.P., 22 Third Street, Box 998, Nipigon, ON, P0T 2J0. **Lake Superior National Marine Conservation Area.**

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

BOURDEAU, P.E.[1], PANGLE, K.L.[2], VANDERPLOEG, H.A.[3], and PEACOR, S.D.[1], [1]Michigan State University, East Lansing, MI; [2]Central Michigan University, Mt Pleasant, MI; [3]Great Lakes Environmental Research Laboratory, Ann Arbor, MI. **The effect of *Bythotrephes* on *Daphnia* vertical distribution in Lake Michigan.**

We examine Daphnia mendotae's vertical migration response to Bythotrephes in Lake Michigan based on pump samples taken over 6 years between 2004-06 and 2009-11. We identify an intermediate Bythotrephes density above which Daphnia nearly always shows deep migration, and below which Daphnia is deeper as a function of Bythotrephes mean depth. This latter result is predicted by an optimization model, which predicts that Daphnia should avoid Bythotrephes even at relatively low Bythotrephes density. We also find that Daphnia vertical position is positively correlated (i.e. deeper) with light intensity and epilimnion depth, and that Daphnia appear to be deeper in later summer months due to risk from fish. Interpreting the effect of Bythotrephes on Daphnia vertical position is therefore complicated, in part due to other multiple and likely interacting factors influencing Daphnia. We briefly present findings for other zooplankton, including a very strong correlation between Daphnia and cyclopoid vertical position. Elucidating how Bythotrephes affects zooplankton vertical distribution across different environmental contexts will aid in predicting the impact of Bythotrephes in Lake Michigan's food web, because zooplankton vertical distribution affects zooplankton reproduction and spatial overlap with other predators. *Keywords: Spatial distribution, Daphnia mendotae, Lake Michigan, Bythotrephes cederstroemii.*

BOURGEAU-CHAVEZ, L.L.[1], SCARBROUGH, K.[1], JENKINS, L.K.[1], RIORDAN, K.[1], POWELL, R.[1], BROOKS, C.N.[1], KOWALSKI, K.P.[2], CARLSON MAZUR, M.L.[2], LAUBACH, Z.[1], BANDA, E.C.[1], and HUBERTY, B.[3], [1]Michigan Tech Research Institute, 3600 Green Ct., Ste. 100, Ann Arbor, MI, 48105; [2]USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105; [3]U.S. Fish & Wildlife Service Region 3 Ecological Services, 5600 American Blvd, West; 10th Floor, Bloomington, MN, 55437. **Coastal Great Lakes Detection and Mapping of the Invasive *Phragmites australis* Wetland Species with ALOS PALSAR Imagery.**

Phragmites australis, an invasive plant that can form dense monocultures, causing negative impacts on coastal Great Lakes wetlands by reducing ecosystem services including wildlife habitat. Through Great Lakes Restoration Initiative funding, ALOS PALSAR imagery was used to map the invasive plant across U.S. coastal Great Lakes wetlands, creating the first U.S. basin-wide distribution map of this species. Methods included maximum likelihood classification of multi-season data from the Japanese ALOS PALSAR L-band (23 cm wavelength) HH and HV polarization sensor. L-band imaging radar data are sensitive to differences in plant biomass and inundation patterns, allowing for the delineation of the tall (up to 5 m), high-density, high-biomass *Phragmites* wetland stands. Extensive field collections of training and randomly selected validation data were conducted in 2010-11 to aid in mapping and for accuracy assessments. These maps are being used as part of a USGS Great Lakes Science Center and USFWS National Wetlands Inventory program to identify major environmental drivers of invasive *Phragmites* distribution, to assess areas vulnerable to new invasion, and to provide this information through a decision support http://cida.usgs.gov/glri/phragmites/.
Keywords: Phragmites, Desision support, RADAR.

BOWEN, A.K.[1] and GOEHLE, M.A.[2], [1]USFWS - Alpena FWCO, 480 W. Fletcher St., Alpena, MI, 49707; [2]USFWS - Lower GL FWCO, 1101 Casey Rd., Basom, NY, 14013. **Surveillance for Ruffe in the Great Lakes.**

The Eurasian ruffe Gymnocephalus cernuus (ruffe), a member of the Percidae family, was first detected in the Great Lakes during the mid 1980s. It was likely introduced via ballast water from an ocean-going ship. Due to its increase in abundance and expansion in western portions of Lake Superior, it was designated an aquatic nuisance species by the Aquatic Nuisance Species Task Force in 1992. The Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 authorized the design and implementation of a Ruffe Control Plan. The plan was drafted in 1995 and revised in 1996 with the goal of preventing or delaying the spread of ruffe in the Great Lakes and inland waters. Surveillance "to find newly established populations of ruffe" is one of eight objectives identified to meet the goal of the plan. Surveillance efforts targeting ruffe were initiated in Lake Superior in 1992 by the U.S. Fish and Wildlife Service and the Ontario Ministry of Natural Resources. Since that time, surveillance has expanded across the Great Lakes. This discussion will provide background on the Great Lakes ruffe surveillance program, current efforts, and where the program may go into the future. *Keywords: Invasive species, Fish, Monitoring.*

BOYER, G.L.[1], SATCHWELL, M.F.[1], EFFLER, S.W.[2], PERKINS, M.G.[2], and O'DONNELL, D.[2], [1]Department of Chemistry, State University of New York, College of Environmental Science and Forestry, Syracuse, NY, 13210; [2]Upstate Freshwater Institute, Inc., P.O. Box 506, Syracuse, NY, 13214. **Two Case Studies on the Use of Near Real Time Monitoring Systems to Determine Nutrient Loads to Lake Ontario; Evaluating the Importance of Episodic Events.**

The near-shore regions of Lake Ontario in New York State are fed by a number of major tributaries. The Genesee River and the Oswego River are especially important sources of phosphorus to the near-shore region as they drain large heavily agricultural watersheds. An accurate estimate of nutrient loads coming from these systems is critical component of any nutrient management plan for the near shore region. These loads are usually estimated using a limited set of discrete observations of nutrient concentrations and continuous measurements of flow rate (e.g., USGS gauges. Loading estimates then become an exercise in how to best estimate concentrations for the intervals with no observations. We have recently enhanced this approach through the installation of near real time monitors for 10 um filtered soluble reactive phosphate (SRP10 - Wet Labs Cycle P) and nitrate (ISUS SUNA nitrate sensor) at the mouth of the Oswego and Genesee Rivers. Observations from these stations were compared to traditional grab samples collected on a periodic basis. Data quality and the nutrient loads estimated from this system in the Oswego River showed excellent agreement with that determined using the more traditional approach. Sensitivity analysis, advantages and disadvantages of the use of these system wwill be presented. *Keywords: Lake Ontario, Nutrients, Monitoring.*

BRANDL, S.C.[1], SCHREIER, B.[3], CONRAD, J.L.[3], SCHUMER, G.[2], MAY, B.P.[1], and BAERWALD, M.R.[1], [1]Genomic Variation Lab, UC Davis, 1 Shields Ave, Davis, CA, 95616; [2]Aquatic Ecology Section, Department of Water Resources, 3500 Industrial Blvd, West Sacramento, CA, 95619; [3]Cramer Fish Sciences, 13300 New Airport Road, Suite 102, Auburn, CA, 95602. **Quantifying predation on larval native fish using genetic barcodes found in gut contents.**

Predation by non-native fish has been implicated in the decline of several fish species native to the San Francisco Bay estuary. Our objective is to investigate the frequency of predation on these species by identifying species in predator guts using mitochondrial barcode genes. This genetic approach offers notable advantages over visual gut contents studies--the sensitivity of the method allows us to identify species long after they have been digested and detection predation on organisms composed of soft tissue, namely larval fish is possible. The corollary to the predation study is its implication in habitat restoration. The data on incidence of predation will be used to identify locations non-native piscivores prey heavily on at-risk species. Predation "hot spots" will be analyzed in relation to a number of environmental data taken during sampling. Factors that correlate with undesirable predation can be targeted for future habitat restoration efforts. Topics addressed will include recent projects using species-specific qPCR assays as well as future methods using next-generation sequencing. *Keywords: Genetics, Predation, Food chains.*

BRATTON, J.F., NOAA Great Lakes Environmental Research Laboratory, 4840 South State Rd, Ann Arbor, MI, 48108. **A Conceptual Typological Model for Coastal Environments in the Great Lakes.**

In order to scale up scientific understanding and management gained from local coastal studies and actions in the Great Lakes to the regional and basin scales, it is necessary to develop an appropriate coastal typology. Factors to consider in this task would include geology, ecology, climate, bathymetry, river influence, and development history. Several efforts to develop coastal categorization schemes are currently underway, and all of these are contributing to an improved ability to conceptualize, study, and manage the Great Lakes. *Keywords: Great Lakes basin, Coastal Typology.*

BRECK, J.[1] and RUTHERFORD, E.S.[2], [1]University of Michigan Institute for Fisheries Research, 1109 N. University Ave, Ann Arbor, MI, 48109; [2]NOAA GLERL, 4840 S. State Rd, Ann Arbor, MI, 48108. **Forecasting Impacts of Future Invaders on Lake Erie's Food Web.**

The Great Lakes are threatened by many potential and newly-arrived aquatic invasive species (AIS). Golden mussel, killer shrimp, hydrilla and snakehead threaten to invade the Great Lakes and disrupt aquatic food webs and fisheries. Eurasian ruffe has established in the nearshore areas of Lake Superior and Green Bay, and will invade other shallow areas of the Great Lakes that are warmer and more productive. We used a calibrated Ecopath with Ecosim (EwE) food web model of Lake Erie to evaluate the impacts of each of these species on the food web structure, fish production and fisheries of Lake Erie. We will forecast the responses of Lake Erie's food web to long-term equilibrium biomass of these different AIS over a range of nutrient loading scenarios, and evaluate uncertainty in model forecasts. *Keywords: Ecosystem forecasting, Lake Erie, Invasive species.*

BREEDERLAND, M.A., Michigan Sea Grant Extension, 520 W Front St. STE A, Traverse City, MI, 49684. **Infrastructure & Maintenance in Michigan Working Waterfronts: Broken Funding Mechanisms & Community Impacts.**

A functional working waterfront depends on coastal infrastructure protection and navigable depth from the water side as well as intentional community land-use planning, typically from the local government and community. In the 8 Great Lakes Coastal States, the US government has responsibility for 60 federal "commercial" harbors and 80 "shallow-draft/recreational" harbors. While the US Army Corps of Engineers is authorized to safeguard navigation activities in the federal harbors from waves and ice, navigation structures also provide critical flood/storm damage protection for coastal communities and the buildings, roads, and facilities in these communities. Most of the Federal coastal protection structures were built between 1860 and 1940 and have not had adequate maintenance due to broken funding mechanisms in Congress. Currently, near record-low lake levels, particularly in Lakes Michigan-Huron, has further put these aging structures at risk as most structures have been built on now-exposed wooden timber cribs, accelerating their deterioration. This presentation will detail

impacts to coastal working waterfront communities if structures are not fixed, discuss federal and state/local funding mechanisms and challenges, and suggest short and long-term strategies for managing resilient coastal communities. *Keywords: Lake Michigan, Infrastructure, Planning, Dredging, Coasts.*

BREIDENBACH, V.K.S.[1], FRENCH, N.[2], DEPINTO, J.V.[3], and HOLMBERG, H.P.[4], [1]LimnoTech, 2828 Branch St., Duluth, MN, 55812; [2]Minnesota Pollution Control Agency, 525 Lake Avenue South, Duluth, MN, 55802; [3]LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108; [4]LimnoTech, 2217 Vine Street, STE 205, Hudson, WI, 54016. **A Coordinated Approach to Restoration: the St. Louis River AOC Implementation Framework in Action.**

Resource managers in the bi-state St. Louis River AOC have been working together to develop an Implementation Framework for delisting the AOC since spring of 2011. Through the Framework process, involved stakeholder groups developed "blueprints" for each Beneficial Use Impairment (BUI) that identified the actions necessary for BUI removal. From these stakeholder-developed products, the final Roadmap for Delisting the AOC is being developed by the Minnesota and Wisconsin partner agencies, the Fond du Lac Band of Lake Superior Chippewa, and the St. Louis River Alliance. The Framework process has allowed the AOC partners to develop a queue of prioritized projects such that when funding opportunities arise, they are ready to respond with requests for their next set of prioritized projects. Project coordination and management responsibilities are being shared among AOC partners across state lines. The Framework process is moving this complex AOC quickly forward towards delisting in an unprecedented fashion. It also supports the development of a process for long-term adaptive management of the system beyond delisting. *Keywords: St. Louis River AOC, Restoration, Remediation.*

BRENDEN, T.O., TSEHAYE, I., BENCE, J.R., and JONES, M., Quantitative Fisheries Center, Michigan State University, East Lansing, MI, 48824. **Comparison of Chinook Salmon Population Demographics and Fishery Characteristics among Lakes Michigan, Huron, and Ontario Inferred from SCAA Assessment Models.**

The introduction and continued stocking of Chinook salmon in lakes Michigan, Huron, and Ontario is credited with having reduced densities of exotic planktivorous fishes and created high-quality recreational fisheries. The status of the Chinook salmon populations in these lakes is believed to have recently diverged, with the population in Lake Huron severely depressed, and the populations in lakes Michigan and Ontario continuing to support thriving fisheries. Using predictions from statistical catch-at-age models developed for each of the lakes, we compare and contrast population demographics and fishery characteristics among the three populations. Whereas in lakes Huron and Ontario, age-1 and older abundances were estimated to have declined during the late 1980s and 1990s, in Lake Michigan abundance have been relatively stable since the mid 1980s. Abundance in Lake Ontario has been relatively stable since the late 1990s, while in Lake Huron abundances continued to decline throughout the 2000s. Recreational fishing effort has declined and recreational fishing catchabiility has increased across all three

lakes. Fully selected fishing mortality rates in Lake Ontario have generally been much lower than in either lakes Michigan or Huron. As well, mean maturation age has generally been lower in Lake Ontario than the other lakes *Keywords: Assessments, Salmon, Great Lakes basin.*

BRENNAN, A.K., FOGARTY, L.R., JOHNSON, H.E., TOTTEN, A.R., DURIS, J.W., and ISAACS-COSGROVE, N.M., USGS - MI Water Science Center, 6520 Mercantile Way, Suite 5, Lansing, MI, 48911. **Occurrence and Distribution of Fecal Indicator Bacteria and Gene Markers of Pathogenic Bacteria in Great Lakes Tributaries, March-September 2011.**

From March through October 2011, the USGS Michigan Water Science, in conjunction with USGS Water Science Centers in Indiana, Minnesota, Ohio, New York, and Wisconsin, conducted a study to determine the frequency of occurrence of genetic markers of bacterial pathogens and densities of fecal indicator bacteria in tributaries to the Great Lakes. This project was funded as part of the GLRI, and included analysis of 21 sampling locations. 134 samples were collected at USGS stream gaging locations during various flow conditions, and analyzed by the MI-BaRL located at the MI-WSC. The majority of samples were collected according to USGS protocol. Water samples were analyzed for the presence of FIB concentrations as well as pathogen occurrence. FIB concentrations and bacterial pathogen concentrations were analyzed with respect to land use and hydrologic conditions in an effort to describe variability in concentrations. Results of this study will be used to improve the understanding of microbiological water quality in Great Lakes tributaries, and ultimately Great Lakes beaches, with the future goal of determining the relations between the occurrence of bacterial pathogens, FIB, seasonality, water chemistry, and hydrology. Resource managers may also use the results of this study to determine the risks to human health. *Keywords: Tributaries, Microbiological studies, Great Lakes Restoration Initiative (GLRI).*

BRIDGEMAN, T.B., CHAFFIN, J.D., and BICHIER, P., Lake Erie Center, University of Toledo, Oregon, OH, 43616. **Performance of in situ fluorometry during HABs.**

Researchers often rely on proxy measurements in order to estimate the abundance of phytoplankton in lakes. In situ fluorescence of chlorophyll *a* and phycocyanin are common proxies for total phytoplankton and cyanobacteria, respectively. Additionally, the use of fluorometers that are able to discriminate algal categories based on the fluorescence of specific pigments is becoming common. Here we use data from a decade of monitoring in western Lake Erie to evaluate the ability of a variety of in situ probes to characterize phytoplankton, especially during harmful algal blooms (HABs). In situ fluorescence data are compared with extracted chlorophyll *a* measurements and HAB biovolume data. *Keywords: Harmful algal blooms, Monitoring, Lake Erie.*

BRILAND, R.D. and LUDSIN, S.A., 200 Research Center, 1314 Kinnear Rd, Columbus, OH, 43212. **Prey-Fish Community Structure in Lake Erie: Historical Shifts and Their Drivers.**

The Lake Erie basin has experienced numerous anthropogenic perturbations, including nutrient abatement programs, invasive species, land-use change, and fisheries harvest. Herein, we use long-term (1969-2011) fisheries-independent assessment data from two Lake Erie basins that vary in ecosystem productivity, in combination with historical physicochemical data, to explore how these stressors have driven change in the prey-fish community. Our findings suggest that reduced system productivity driven by reduced availability of total phosphorus to the food web underlie a dramatic shift from a pelagic prey-fish assemblage to a benthic-feeding assemblage dominated by invasive species in western Lake Erie. By contrast, both bottom-up and top-down processes appear important in central Lake Erie. Prior to 1988, abundance of adult walleye *Sander vitreus* was most important in explaining variation in the ratio of planktivores to benthivores, whereas tributary inputs of phosphorus during spring was more important during the recent period through apparent bottom-up effects on zooplankton availability to invasive white perch *Morone americana*. Our findings clearly demonstrate how both natural and human-driven gradients in system productivity and top-predator abundance can drive population-level shifts in fish communities. *Keywords: Food chains, Oligitrophication, Fish management, Regime shift, Eutrophication.*

BRINKWORTH, L.A., FLYNN, E.S., HALSTVEDT, M.B., PETERSON, V.F., and MASTERS, R.A., Dow AgroSciences, 9330 Zionsville Road, Indianapolis, IN, 46220. **Aminopyralid (MilestoneTM) Utility in Rangeland Restoration Programs.**

Aminopyralid (MilestoneTM herbicide) was developed by Dow AgroSciences for rangeland, pastures, and non-cropland weed management systems. The herbicide provides excellent efficacy against important noxious and invasive plant species and has a good fit in rangeland improvement, prairie restoration and pasture renovation programs. Aminopyralid provides preemergence and postemergence control of many broadleaf noxious and invasive plants with little to no injury to most rangeland and pasture grasses. Invasive plants in the Acroptilon, Carduus, Centaurea, Chondrilla, Cirsium, Croton, Dipsacus, Hieracium, Hypericum, Leucanthemum, Melilotus, Microstegium, Onopordum, Pueraria, Senecio, Solanum, and Vicia genera are among those controlled by aminopyralid. In collaborative investigations with state and federal state land management and research institutions, many native plant species were determined to be moderately tolerant to tolerant to aminopyralid and their populations recovered following treatment. Aminopyralid can serve as a catalyst to manage invasive plants and facilitate recovery of desirable plants when used a component of integrated rangeland and grassland restoration systems. *Keywords: Ecosystems, Restoration, Invasive species, Forbs, Biodiversity, Weed control.*

BRINKWORTH, L.A., FLYNN, E.S., MASTERS, R.A., and HALSTVEDT, M.B., 9330 Zionsville Road, Indianapolis, IN, 46220. **Factors affecting herbicide selection and use in rangeland restoration programs.**

Invasive plant management is an intrinsic component of plant community restoration projects. Tools available for invasive plant management are: biological control, cultural methods, mechanical methods and chemical control. All methods play a role in an integrated approach to restoration. Herbicides can be useful and cost effective tools to selectively control undesirable plants. Understanding herbicide characteristics is critical to selecting herbicides that best fit a restoration programs. All herbicide interactions in a plant are considered the mode of action and can determine the spectrum of species controlled and the selectivity of the herbicide to desired plants. An herbicide is usually selective within certain rates, environmental conditions, and methods of application. Various methods of application are available and the most effective method can be determined by the characteristics herbicide, by the invading plant itself, the extent of infestation and the topography of the site. Knowledge of herbicide attributes will improve ability to select the herbicides best suited to meet land management objectives.
Keywords: Biological invasions, Restoration, Decision making, Invasive species.

BROOKS, C.N.[1], SHUCHMAN, R.A.[1], GRIMM, A.G.[1], SAYERS, M.J.[1], RAYMER, Z.B.[1], JESSEE, N.L.[1], LIOU, L.[2], and BANACH, D.[1], [1]Michigan Tech Research Institute, 3600 Green Ct., Ste. 100, Ann Arbor, MI, 48105; [2]NASA Glenn Research Center, 21000 Brookpark Road, Cleveland, OH, 44135. **Creating a Representative Lake Erie Time Series of Remote Sensing-based Water Quality Data Sets.**

Remote sensing provides a method to accurately assess water quality for current and historical conditions in large lakes such as Lake Erie. Satellite sensors such as SeaWiFS and MODIS collect data that span large geographic areas and have been in operation for more than a decade, with some satellite programs that have existed since the 1970s. This remote sensing "time machine" allows scientist to analyze a time series of data and determine how water quality conditions have changed, particularly in light of a changing climate. Augmentation of remotely sensed data with sound in-situ measurements allows scientists to gain a deeper understanding of changes in the Great Lakes. This presentation reviews a recent collaborative study between the Michigan Tech Research Institute and the NASA Glenn Research Center that detailed satellite-derived products to assess changes in Lake Erie water quality, described ancillary observations to support the time series analysis, and derived the representative set of products to characterize Lake Erie's water quality and characteristics. Remote sensing analysis outputs included retrieving color-producing agent (CPA) products (chlorophyll, suspended minerals, and dissolved organic carbon concentrations), sediment plume extents, optical water parameters, and harmful algal bloom extents. *Keywords: Lake Erie, Remote sensing, Water quality.*

BROOKS, Y.M.[1], BAUSTIAN, M.M.[1], BASKARAN, M.[2], and ROSE, J.B.[1], [1]480 Wilson Rd. Rm 13, Michigan State Universiy, East Lansing, MI, 48912; [2]Old Main Building Rm. 028, Wayne State University, Detroit, MI, 48202. **Molecular measurements in sediment cores linking pollution, climate and watershed management.**

Lake St. Clair, a small lake connecting Lake Huron and Lake Erie, has a long history of pollution and water quality data. Its sediments are reservoirs for fecal indicator bacteria (FIB), pathogens and nutrient loading. Our objective is to investigate how general and human-specific FIB molecular markers correlate to infrastructure, population, nutrient concentrations, temperature and precipitation using spatial temporal measurements in sediment cores. Specifically, this study will compare cores from two sites, Anchor Bay (AB, core length 58cm), a historically sparsely populated area and agricultural watershed, and the mouth of the Clinton River (CR, core length 86 cm), a heavily populated area and historically polluted watershed. Core chronostratigraphy established with vertical variations of Cs-137 and Pb-210 radionuclides estimated sedimentation rates of ~1cm/yr (core length represents ~58yrs) and ~0.45cm/yr (core represents >150yrs) for CR and AB, respectively. Based on previous research, it is believed that nutrient concentrations are strongly correlated with FIB concentrations in Lake St. Clair sediments. This study will also establish associations between infrastructure, climate change, pollution and water quality on a large temporal scale, in order to determine which factors negatively affect Lake St. Clair water quality. *Keywords: Eutrophication, Fecal contamination, Water quality, Sediment quality.*

BRUNNER, J.[1], WESCOTT, J.[1], BIXLER, A.[1], IRELAND, S.[2], and WODRICH, C.[3], [1]Tetra Tech, 1 South Wacker Drive, 37th Floor, Chicago, IL, 60606; [2]USEPA Great Lakes National Program Office, 77 West Jackson Boulevard, Chicago, IL, 60604; [3]Indiana Department of Natural Resources, 402 W. Washington Street, W261, Indianapolis, IN, 46204. **Contaminated Sediment Remediation and Habitat Restoration: Grand Calumet River and Roxana Marsh.**

Under the GLLA, EPA GLNPO and its non-federal partners funded a project to clean up contaminated sediment and restore habitat along a portion of the Grand Calumet in northwest Indiana. This region is one of the most industrialized areas in the country as well as home to some of the most diverse native plant and animal communities in the Great Lakes Basin. The cleanup has addressed about 730,000 cubic yards (CY) of contaminated sediment. Contaminated sediment was removed through hydraulic dredging and mechanical excavation and a cap was then placed to isolate any remaining contamination. This presentation focuses on a 2.5-mile stretch of the river in Hammond and East Chicago that removed or isolated 577,000 CY of contaminated sediment. A wetland habitat restoration plan was also implemented for this project. Dredging and excavation of Roxana Marsh removed contaminated sediment and also Phragmites from the marsh. The marsh was restored with native plants and an open water pond to provide additional habitat diversity and help prevent the return of Phragmites. This presentation will provide an overview of the remediation and discuss the habitat restoration planning and design considerations, strategies used to overcome challenges during implementation, and lessons

learned and considerations for other similar projects. *Keywords: Sediments, Habitats, Environmental contaminants.*

BRUNNER, J.[1], DURLEY, S.[1], and GERDEMAN, M.[2], [1]Tetra Tech, 1 South Wacker Drive, 37th Floor, Chicago, IL, 60606; [2]City of Toledo, Department of Environmental Services, Toledo, OH, 43604. **Ottawa River Watershed Scrap Yard Pollution Prevention (P2) Program: Reducing Toxics in Stormwater Runoff.**

The City of Toledo, Ohio, and other project partners recently collaborated with the U.S. EPA under the Great Lakes Legacy Act to remediate sediments in the Ottawa River, which is part of the Maumee River AOC. To help control ongoing sources of toxics in the watershed and help ensure long-term success of this remediation and, the City of Toledo, received a Great Lakes Restoration Initiative grant for the to address toxic substances in the watershed. The project engaged local scrap and auto salvage yards and encouraged them to implement P2 options and best management practices (BMP) to improve operations and decrease contaminants in stormwater runoff. The project (1) provided the facilities with customizes P2 tool kits tools and technical assistance to self-implement stormwater BMPs, including oil/water separators and bioretention areas, and (2) evaluated and recognized the facilities' level of success and effectiveness of the measures implemented. The program's approach, tools, and methods used to successfully engage scrap and auto salvage yards in implementing P2 options and BMPs as well as the stormwater sampling results and other measures to evaluate the effectiveness of these efforts in protecting the local watershed will be presented. *Keywords: Urban watersheds, Water quality, Pollution load.*

BRYAN, M.G. and HANN, B.J., Biological Sciences - University of Manitoba, 50 Sifton Rd., Winnipeg, MB, R3T 2N2. **The Implications of Cyanobacteria Blooms on the Base of the Food Web in Lake Winnipeg as Determined by Stable Isotope Analysis.**

Over the past two decades, summer blooms of *Aphanizomenon* spp. and *Anabaena* spp. have been increasing in both size and duration in the north basin Lake Winnipeg. These genera produce blooms that, because of physical and chemical defences, are thought to be inedible to most zooplankton grazers. Blooms of cyanobacteria supplant other phytoplankton, thereby reducing the overall energy supply available to the zooplankton. The fate of the energy contained in the cyanobacteria is unclear. Preliminary analysis revealed that cyanobacteria were not a major component of the gut contents chironomids collected during a summer bloom, nor during the following fall and spring. To determine whether cyanobacteria were being ingested by zooplankton or were sinking and being ingested by chironomids, stable isotope analysis of Carbon and Nitrogen were conducted on samples of phytoplankton, zooplankton, chironomids, and sediments collected from Lake Winnipeg in spring, summer, and fall 2012. The phytoplankton community composition was identified microscopically to determine the relative contribution of cyanobacteria. This work provides insight into the trophic dynamics of the base of the Lake Winnipeg food web. *Keywords: Lake Winnipeg, Stable isotopes, Benthos.*

BRYAN, N.J., MOORHEAD, D.L., and CRAIL, T.D., 2801 West Bancroft St., Mail Stop #604, Toledo, OH, 43606-3390. **Habitat characteristics of a unionid refuge in a western Lake Erie thermal plume.**

Previous studies identified a rich community of unionid mussels living in the thermal plume of the Bayshore Power Plant, Oregon, Ohio. In the summer of 2012, we studied habitat characteristics within this plume: we expected warmer water temperatures, higher POM concentrations, higher organic matter in sediments, and greater coarse sediment mass in the plume. Water temperature averaged 3.8±1.5°C warmer at the plant's outflow than intake, significantly decreased ($p<0.01$) with distance and varied with wind speed. Wind speed also affected both the difference in particulate organic matter (POM) concentrations between the intake and outflow and the change in POM with distance (all $p<0.01$). Wind direction affected ($p<0.01$) differences in dreissenid veliger density between the intake and outflow, with the ratio of live:dead veligers higher at the intake on most dates. A laboratory experiment showed that heating caused significant mortality in veligers ($p<0.01$). Organic matter content in fine (<2mm) surface sediments did not vary but organic matter content in lakebed clay increased with distance ($p<0.05$). The mass of the surface 2-10mm sediment size fraction also increased with distance ($P<0.05$). Thus not all factors considered favorable for unionids were enhanced by proximity to the power plant. *Keywords: Dreissena, Refugia, Unionids.*

BUCKLEY, J.T. and MOSER, R.M., 119 Bovee University Center, Mt Pleasant, MI, 48858.
Crayfish Suppression on Critical Spawning Reefs by Intensive Trapping.

Native fish species in the Great Lakes require spawning reefs for reproduction, but they have been overtaken by invasive species. Rusty crayfish are impacting the recruitment of lake trout, cisco, and lake whitefish through egg predation. This project attempted to reduce rusty crayfish numbers using minnow traps to trap prior to spawning. The goal was to determine if intensive trapping was a successful method of reducing rusty crayfish densities during spawning. Data collected will be used to create a standard operating procedure for depletion trapping of rusty crayfish. Four critical spawning reefs in Lake Michigan were picked for rusty crayfish removal. During summer 2012, minnow traps with large or small openings were set on three reefs in Grand Traverse Bay and one reef in Little Traverse Bay. A total of 1,098 rusty crayfish (586 females, 503 males, and 9 unidentified sex) were removed. Traps with larger openings were more effective at catching male rusty crayfish relative to traps with small openings. The small opening trap was the most effective for catching female rusty crayfish. The large opening traps captured most of the larger male and female rusty crayfish. Using data recently collected, we will be able to better determine if this method was truly effective in increasing recruitment of the native fish species. *Keywords: Lake Michigan, Rusty crayfish, Invasive species, Lake trout.*

BUNNELL, D.B.[1], WARNER, D.M.[1], DAVIS, B.M.[1], KEELER, K.M.[2], VINSON, M.R.[3], YULE, D.L.[3], NALEPA, T.F.[4], FAHNENSTIEL, G.L.[5], POTHOVEN, S.A.[4], and VANDERPLOEG, H.A.[4], [1]USGS Great Lakes Science Center, Ann Arbor, MI; [2]University of Michigan, Ann Arbor, MI; [3]USGS Great Lakes Science Center, Ashland, WI; [4]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI; [5]Michigan Technological Research Institute, Ann Arbor, MI. **Using upper trophic levels to test the nearshore shunt and mid-depth sink: is the offshore an aquatic desert?**

By altering internal nutrient cycling (e.g., "nearshore shunt", "mid-depth sink"), dreissenid mussels have been hypothesized to reduce phosphorus (TP) available to offshore waters of the Great Lakes. This reduced TP underlies declines in offshore phytoplankton biomass in Lake Michigan during spring, although effects on higher trophic levels are unknown. Herein, we describe seasonal estimates of TP, chlorophyll, benthic invertebrates, zooplankton, and prey fishes from nearshore (18 m), intermediate (46 m), and offshore (110 m) depths at two sites (Frankfort, Sturgeon Bay) in Lake Michigan in 2010. We contrast these values with comparable 2011 measurements from one site in Lake Superior (Apostle Islands), where dreissenid mussels do not occur. Preliminary analyses from Lake Michigan do not perfectly conform to predictions. For example, TP was lowest at 110 m during August, September and October, but not during May (pre-stratification, when mussels could access the entire water column). Chlorophyll was always highest at intermediate and deep depths. The highest biomass of benthic invertebrates always occurred at intermediate depths. The highest biomass of zooplankton and fish varied with depth through time. Lake Superior values were unavailable at the time of submission.
Keywords: Food chains, Nutrients, Fisheries.

BURKETT, E.B., 440 Church St., Ann Arbor, MI, 48109. **Long-term Impacts of Invasive Round Gobies (*Neogobius melanostomus*) on Benthic Fish Community and Diet in the St. Clair River, Michigan.**

Round gobies (*Neogobius melanostomus*) were documented within the St. Clair River in 1990, and subsequently impacted native benthic fishes that occupy the same ecological niche. The goal of this study was to identify long-term changes in species diversity and fish diets within the St. Clair River associated with the round goby invasion. We compared fish density and diet data gathered during extensive sampling conducted in 1993 and 1994 with similar data collected in 2011. Diel sampling of invasive and native fish was conducted at multiple depths, using seine and trawl nets, from May to December. We used displacement techniques and the Schoener Index method to assess diet overlap between round gobies and native fishes. Results indicate drastic changes in the benthic fish community between 1993-1994 and 2011, and one species, the mottled sculpin (*Cottus bairdii*) has likely been nearly extirpated from the St. Clair River. Diet overlap between round gobies and native fishes varies spatially, temporally, and ontogenetically, and implies a potential direct, negative impact on native fish populations. Our results suggest a causal linkage between round goby invasion and establishment, and long-term changes in fish species diversity within the St. Clair River. *Keywords: St. Clair River, Diets, Round goby.*

BURLAKOVA, L.E.[1], KARATAYEV, A.Y.[1], BOSSENBROEK, J.M.[2], ZANATTA, D.T.[3], TULUMELLO, B.L.[1], KREBS, R.A.[4], PATERSON, W.[3], and GRIFFITH, T.[3], [1]Great Lakes Center, Buffalo State College, 1300 Elmwood Ave., Buffalo, NY, 14222; [2]2Department of Environmental Sciences, Lake Erie Center, University of Toledo, Oregon, OH, 43618; [3]3Biology Department, Institute for Great Lakes Research, Central Michigan University, Mount Pleasant, MI, 48859; [4]Department of Biological Sciences, Kent State University, Kent, OH, 44242.
Assessing Unionid Refuges and Dreissenid Impacts in the Lower Great Lakes.

The invasion of zebra mussels (*Dreissena polymorpha*) and quagga mussels (*Dreissena rostriformis bugensis*) has threatened the survival of native unionid mussels in the Great Lakes. Using funding from the Great Lakes Fish and Wildlife Restoration Act, we conducted extensive unionid surveys in lakes Erie and St. Clair in 2011. Data collected during this survey, and environmental GIS layers of the nearshore areas of Lake Erie were used with Maxent to predict potential unionid habitats in Lake Ontario. In the summer of 2012, we surveyed a total of 46 sites at 26 locations in bays, coastal wetlands, and tributary mouths of Lake Ontario, collecting over 1800 live unionids belonging to 10 species. We found that the model successfully predicted many unionid refuges in Lake Ontario. Most of the live unionids found during our study in the lower Great Lakes were free of dreissenids, and infested unionids had fewer attached dreissenid mussels compared to the high infestation rate of unionids shortly after the dreissenid invasion. The approach used in the lower Great Lakes will be extended to develop predictive models of refuges in Lakes Michigan and Huron, and in designing management strategies to provide additional unionid habitats. *Keywords: Unionids, Lake Ontario, Dreissena, Refugia.*

BURTNER, A.B.[1], GOSSIAUX, D.C.[2], JOHENGEN, T.H.[1], and PALLADINO, D.[1], [1]Cooperative Institute for Limnology and Ecosystems Research, 440 Church St., Ann Arbor, MI; [2]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State St., Ann Arbor, MI. **A Multi-year Comparison of *Microcystis aeruginosa* Blooms and Water Quality in Western Lake.**

Microcystis aeruginosa is a colonial cyanobacteria which forms most of the harmful algal blooms (HABs) in the Great Lakes. Concentrations of microcystin, the hepatotoxin produced by *M. aeruginosa*, can be measured by two different procedures: high-performance liquid chromatography (HPLC) and commercially available immunoassay kits (ELISA). Microcystin concentrations in Western Lake Erie were monitored using both HPLC and ELISA from 2010 through 2012, years in which HABs varied greatly in both timing and severity. Preliminary concentration data from 2003-2005 ranged from 0.1-4 µg /L, occasionally exceeding the World Health Organization's recommended drinking water limit of 1µg/L. Data from 2010-2012 regularly exceeded 1 µg/L and peaked at over 1500 µg/L indicating dramatic HABs during our focal field seasons. Water quality variables, including total phosphorus, soluble reactive phosphorus, nitrate, ammonium, particulate nitrogen and carbon, and chlorophyll-α were also measured. Our preliminary results show that these variables as well as abiotic factors such as meteorological conditions influence cyanobacteria diversity and abundance and ultimately microcystin concentrations. Further understanding of these relationships coupled with new in situ

instruments may prove useful for further HAB modeling. *Keywords: Microcystis, Lake Erie, Nutrients.*

BYAPPANAHALLI, M.N., KATARZYNA, P.K., ASHLEY, A.M., and WHITMAN, R.L., U.S. Geological Survey, Great Lakes Science Center, Lake Michigan Ecological Research Station, 1100 N. Mineral Springs Road, Porter, IN, 46304. **Macroinvertebrate response to decomposing *Cladophora* and potential *Clostridium botulinum* bioaccumulation.**

There is growing speculation that the algal benthic macroinvertebrate community plays an important role in botulism outbreaks in piscivorous birds. In laboratory exposure studies, small amounts of decayed algal matter in buffered water (1:1500) or diluted algal extracts (approximately 1:100) were extremely toxic to mussels, worms, and amphipods, resulting in die-off within 15-24 hours. In mesocosms spiked with surrogate bacteria, including *Clostridium perfringens* (congener to *Clostridium botulinum*), the amphipods and mussels concentrated the bacteria through attachment and by ingestion. Spiked bacteria were also recovered in mussels' pseudofeces, indicating benthic feeding results in bacterial accumulation, with subsequent deposition onto algae or other environmental substrates. *C. botulinum* toxin gene (bontE) was not detected by polymerase chain reaction (PCR) in *Cladophora* mats collected from beaches in northern Lake Michigan. The bontE gene, however, was found in 23% of the algal mats and/or their extracts after incubation under anaerobic conditions for up to 5 weeks, indicating that *C. botulinum* concentrations in field samples were below the detection limit by PCR. These studies suggest that algal benthic macroinvertebrates play a significant role in trophic pathways of avian botulism. *Keywords: Microbiological studies, Clostridium, Macroinvertebrates, Avian botulism, Cladophora, Wildlife health.*

CAI, M.[1], KOVALENKO, K.E.[2], JOHNSON, L.B.[1], CIBOROWSKI, J.J.H.[2], and BRADY, V.J.[1], [1]Center for Water and the Environmental, Natural Resources Research Institute, University of Minnesota Duluth, 5013 Miller Trunk Highway, Duluth, MN, 55811-1442; [2]Department of Biological Science, University of Windsor, Windsor, ON, N9B 3P4. **Modeling land and water stress impacts on macroinvertebrates in the Great Lakes costal wetland.**

We aimed to identify the impact path and compare relative importance of different stress types on macroinvertebrate richness and abundance using structural equation modeling. Between 2001 and 2003, macroinvertebrates were collected from 101 coastal wetlands stratified randomly across the Great Lakes. Local landscape characteristics, disturbance features, water quality and vegetation types were assessed at sites. We hypothesized that land-based stressors directly modify water quality and aquatic vegetation, which further influence macroinvertebrate communities. Of the direct effects identified, vegetation exerted the strongest impact to invertebrates by enhancing their richness and abundance. Correlations between water quality and benthos were negative and relatively weak. Moreover, vegetation rather than water quality was the main pathway by which land stress indirectly alters invertebrate community. Of the various land stress types, local disturbance was generally more strongly related to benthic richness and abundance than watershed factors. In ecoprovince-based models, agriculture displayed a positive

relationship to invertebrate richness in less disturbed northern ecoprovince, but the relationship was negative in the mesotrophic southern ecoprovince. In both regions, development produced stronger effects than agriculture. *Keywords: Coastal wetlands, Environmental effects, Benthos.*

CAMPBELL, A.J. and WU, C.H., University of Wisconsin Madison, 1269D Engineering Hall, 1415 Engineering Drive, Madison, WI, 53706. **Kinematics and Dynamics of Surface Waves through Ice in Lakes.**

Wave propagation through ice is a complex physical process that occurs in cold oceanic or lacustrine environments. The presence of ice-waves in both coastal and offshore waters can create severe issues such as navigation hazards, elevated wave-ice loading on structures, or shoreline/bluff erosion. Therefore, quantifying kinematics and dynamics of surface water waves through ice is crucial for proper design and management of cold water regions. In this talk we will present an innovative stereo imaging technique to examine surface wave motions under three distinct ice types: brash, frazil, and pancake. Results show that ice plays an important role in affecting wave energy transformation and propagation in comparison to surface waves without ice. Specifically, brash ice is observed to increase dominant frequency while pancake and frazil ice decrease dominant frequency. This shift of the dominant frequency causes a change in the dominant wave propagation speed. In addition, wave energy decays exponentially in frazil and pancake ice while remaining relatively constant in brash ice, with pancake ice causing larger attenuation than frazil ice. Overall, these results provide detailed insight into ice-wave propagation characteristics previously unreported on. *Keywords: Remote sensing, Ice, Waves.*

CAMPBELL, J.M. and TURNER, S.M., Mercyhurst University, 501 East 38th Street, Erie, PA, 16546. **A review on mechanisms of skin tumor formation in brown bullheads (*Ameiurus nebulosus*) in Lake Erie and prospective analysis of genetic and microbiome factors.**

Decades of fish sampling to monitor tumors in brown bullheads in Lake Erie have not yet successfully identified the cause of external tumors in this sentinel species, and the unresolved issue remains a stumbling-block in delisting Great Lakes Areas of Concern. The relative importance of the main types of external tumors detected in brown bullhead populations varies in space and time, suggesting that multiple etiologies are involved. A general explanatory model and review of potential causes of external tumors in *Ameiurus nebulosus* indicate possible involvement of microbial and other agents, as well as genetically-based immunodeficiencies. This paper will summarize progress to-date in addressing these questions, and will offer a proposed framework for systematically defining a causative mechanism via experimentation and genetic analyses -- using brown bullhead from Lake Erie sites presenting varied histories of environmental degradation. *Keywords: Biomonitoring, Fish diseases, Lake Erie.*

CAMPBELL, M.L.[1] and COOPER, M.J.[2], [1]University of Windsor, Windsor, On, N9B 3P4; [2]University of Notre Dame, Notre Dame, IN, 46556. **Economy of the Great Lakes Region.**

The economic capacity of the Great Lakes St. Lawrence River Basin rivals the largest industrialized economies in the world today. After a brief discussion of historical and current economic trends in the regions industry organization, sector contribution to GDP and employment, an exploration of the effects of other drivers on the regional economy follows. Acknowledging the significance of the natural endowments of the region on the economy, this paper addresses the fact that certain sectors such as agriculture, shipping and tourism, have a greater impact and/or reliance on the environmental health of the region than their contribution to the economy would suggest. The impacts of the economic primacy of manufacturing as the main driver of bilateral trade in the region are also addressed. An analysis of the regions automotive industry, renewable energy industry, and bioeconomy, and their interaction with other drivers such as governance, water quality and quantity is utilized to construct possible future economic scenarios for the region. The goal is to synthesize realistic policy recommendations that deliver a holistic and sustainable approach to the continued economic health of the Great Lakes.
Keywords: Great Lakes basin, Economic impact, Economic evaluation.

CARLSON MAZUR, M.L.[1], PRATS, K.[1], IDLEMAN, E.[1], ANTONELLI, S.[1], GRANNEMAN, J.[4], SCHAEFFER, J.S.[2], and FITZPATRICK, F.A.[3], [1]Boston College, Dept. of Earth & Env. Sciences, 140 Commonwealth Avenue, Chestnut Hill, MA, 02467; [2]USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105; [3]USGS Wisconsin Water Science Center, 8505 Research Way, Middleton, WI, 53562; [4]University of South Florida, College of Marine Science, 140 7th Avenue Sout, St. Petersburg, FL, 33701. **Impacts of River and Lake on Mixing and Wetland Distribution in Rivermouth Ecosystems.**

Not only are Great Lakes rivermouths the epicenters of human interaction with the Great Lakes, ecologically they represent dynamic locations where lake and landscape meet. The interplay between river flows and backflow caused by lake seiches results in complex patterns in mixing and wetland distribution. The specific dynamics of these patterns, however, and the impacts of alteration to natural hydrogeomorphic function, are largely unknown. Using conservative tracers, we studied four rivermouth ecosystems to determine present-day locations of the dynamic mixing front in relation to the opposing riverine and lake flows. We also mapped wetlands from historic air photos to assess changes in wetland distribution through time and related these changes to the relative magnitudes of the opposing flows. Findings suggest that relationships that predict mixing locale from river discharge and lake level are specific to each rivermouth. Furthermore, whereas mixing locale is primarily influenced by river flow, wetland distribution appears to be governed by lake level. For biota utilizing habitats generated by mixing and wetland areas, the proximal coincidence of these resources may be important. A better understanding of these habitat dynamics though time will help us better manage and restore these critical rivermouth ecosystems. *Keywords: Ecosystems, Estuaries, Hydrogeomorphology.*

CARRICK, H.J.[1], BUTTS, E.[1], CAFFERTY, E.[1], SCHUBERG, D.[1], STIMETZ, A.[1], and FAHNENSTIEL, G.L[2], [1]Institute for Great Lakes Research, Central Michigan University, Mount Pleasant, MI, 48859; [2]Great Lakes Research Institute, Michigan Technological University, Houghton, MI, 49931. **Where Have the Diatoms Gone? A Shift Towards Dominance by the Microbial Food Web in Lake Michigan.**

Since 2005, unprecedented changes in the open water region of southern Lake Michigan have been observed and documented (see Fahnenstiel et al. 2010). These remarkable changes appear to be confined to the late winter to spring period, such that the typical diatom bloom that normally occurred at this time, is now gone. Here, we compare the biomass, taxonomic composition, and size distribution for phytoplankton and components of the microbial food web (algae and protoza) from data collected during two periods: 1980's (pre-dresseid mussels) and 2011 (post dresseid mussels). Our data shows an overall decline in phytoplankton biomass and a shift towards dominance by smaller-sized species from pre to post-mussel periods. A large decline (>50%) in phytoplankton biomass was observed in 2011 compare with 1983-87. The recent shift towards smaller species was reflected in a doubling of chlorophyll in the <2 um category (change from 25% to 50%). While biomass of microzooplankton was similar between periods, the assemblage appears to have shifted towards dominance by smaller species (flagellates and small cilitates), particularly in the spring. These data suggest that in Lake Michigan, traditional trophic link between diatoms and crustacean zooplankton has been replaced (in part) by the link between small phytoplankton and protozoa. *Keywords: Diatoms, Food chains, Dreissena.*

CHA, Y.K.[1] and STOW, C.A.[2], [1]G110 Dana Building 440 Church Street, Ann Arbor, MI, 48109; [2]4840 South State Road, Ann Arbor, MI, 48108. **Saginaw Bay phosphorus target reevaluation using a Bayesian hierarchical observation error network (Saginaw Bayes).**

The 2012 amendments to the Great Lakes Water Quality Agreement require evaluation of the 1978 target phosphorus loads and development of in-lake phosphorus concentration targets for each Great Lake. Our study examined the relationships among river total phosphorus (TP), lake TP, and lake chlorophyll a (Chl) concentrations in Saginaw Bay, Lake Huron, for the years 1969-2009, which span both periods of before and after the invasion of dreissenid mussels. We employed an observation error model that accounts for the measurement and sampling errors of annual mean estimates. Our approach provides a better estimate of the true underlying relationships between the response and predictor variables than does the common practice, and improves predictive precision. Our results indicated that lower lake TP and Chl concentrations are predicted for a given TP load since the mussel invasion, which is consistent with post-invasion changes that have been documented in Saginaw Bay and other systems. Lake TP and Chl concentration predictions responded sensitively to changes in TP load and lake TP over specific ranges, including the region where the target TP load and lake TP level are set. Our model offers a basis for evaluating target tributary loads and concentrations as well as in-lake criteria. *Keywords: Phosphorus, Phytoplankton, Dreissena.*

CHADDERTON, W.L.[1], ELGIN, E.[2], JERDE, C.L.[3], ROTH, A.[4], DE PALMA DOW, A.[5], KELLER, D.[6], MYSOREKAR, S.[1], MCNULTY, J.[3], and BARNES, M.A.[3], [1]The Nature Conservancy, 1400 East Angela - Unit 117, South Bend, IN, 46617; [2]2500 University Drive N.W. 256, Department of Biological Sciences, University of Calgary,, Calgary, AB, T2N 1N4, Canada; [3]Unit 117, 1400 East Angela Blv, University of Notre Dame Environmental Change Initiative,, South Bend, IN, 46617; [4]1530 Cleveland Avenue N., Department of Forest Resources, University of Minnesota,, St Paul, MN, 55108; [5]480 Wilson Road, Department of Fisheries and Wildlife, Michigan State University,, East Lansing, MI, 48824; [6]Indiana DNR, 402 W. Washington St, Rm W273, Indianapolis, IN, 46204. **Aquatic plant surveillance - Results of a rapid Hydrilla verticillata delimitation survey in south-western Laurentian Great Lakes Region.**

We report here on the results of a rapid delimitation survey of 719 sites (principally boat landings) on 581 inland lakes in Indiana, southern Michigan, eastern Illinois and Ohio, as well as 119 public landings on the Ohio River and its tributaries. Surveillance was primarily motivated by recent incursions of Hydrilla verticillata into Lake Manitou, in Northern Indiana. Survey teams recorded the presence of introduced and native plants species, zebra mussels and Chinese mystery snails. Lakes were predominantly surveyed using a 30 minute snorkel method that produced higher rates of detection than standard rake toss methods that have historically been deployed to search for invasive species in the region. Snorkelers, accompanied by a kayaker, generated distributional data for 12 invasive aquatic plant and mollusk species and 72 native plant taxa. No new populations of hydrilla were observed at the inland lakes surveyed, confirming that this species is not widespread in public waters of the region surveyed. However, hydrilla was found to be well established in the upper Ohio River with thick beds and surface mats observed around most landings between New Matamoras, OH and Rome, OH. Implications for future surveillance efforts are discussed. *Keywords: Biological invasions, Invasive species.*

CHAFFIN, J.D., SIGLER, W.V., and BRIDGEMAN, T.B., Lake Erie Center and Dept of Environmental Sciences, University of Toledo, Toledo, OH, 43607. **Tracking the Unprecedented Lake Erie *Microcystis* Bloom of 2011 using Denaturing Gradient Gel Electrophoresis.**

The Lake Erie *Microcystis* bloom of 2011 covered the majority of the western basin (WB) in July and August and reached the central basin (CB) in October. Our study compared genetic diversity of *Microcystis* across the lake and throughout the summer to determine how *Microcystis* responds to changes in dissolved nutrients. Furthermore, two major tributaries (Maumee and Sandusky Rivers) and lake sediments were analyzed prior to bloom formation to investigate source populations. Denaturing gradient gel electrophoresis was used to generate molecular fingerprints of the 16S-23S rRNA ITS. Dendrograms revealed the October CB bloom and the July and August WB blooms were more than 50% similar with several ubiquitous bands. Genetic diversity of *Microcystis* in high biovolume samples was consistent throughout the summer and among locations, despite the large difference of dissolved nutrient concentrations. Dendrograms also indicated that the sediments were a more likely source of the blooms, rather than the rivers. Overall, this study suggests that *Microcystis* in Lake Erie originated from the lake

sediments, and the bloom that began in western Lake Erie spread eastward across the lake. *Keywords: Microcystis, Lake Erie, Populations.*

CHAPMAN, D.C., ANDERSON, K.R., BROTHERS, E., and LUCEY, M., USGS Columbia Environmental Research Center, 4200 New Haven Road, Columbia, MO, 65201. **Non-planktonic alternative food sources for bighead and silver carps in the Great Lakes.**

In recent years concern has mounted over the potential for invasive bighead (Hypophthalmichthys nobilis) and silver carps (H. molitrix) (together the bigheaded carps) to colonize the Great Lakes. Bioenergetics models have indicated that planktonic foods may be inadequate for bigheaded carps to successfully invade large portions of the Great Lakes. Bigheaded carps are primarily planktivores but in some cases switch to non-planktonic food such as detritus. We evaluated Cladophora and dreissenid mussel psuedofeces as potential food sources abundant in the Great Lakes that might be used by bigheaded carps in lieu of plankton. Cladophora is a filamentous alga that is common in the littoral zones of the Great Lakes and has become much more abundant since the dreissenid mussel invasion. Dreissenid mussel pseudofeces are fine, organically enriched particles that are highly available and also result from the dreissenid invasion. We used feeding experiments, underwater video and bomb calorimetry to evaluate fish growth and feeding behavior and caloric content to test the viability of these alternative foods. Results show that bigheaded carps can maintain their weight on both Cladophora and dreissenid mussel psuedofeces suggesting that alternative foods exist in the Great Lakes. *Keywords: Carp, Cladophora, Diets, Pseudofeces, Invasive species.*

CHAPRA, S.C.[1], DOVE, A.[2], and DOLAN, D.M.[3], [1]Civil and Environmental Engineering, Tufts University, Medford, MA, 02155; [2]Water Quality Monitoring and Surveillance Ontario, Environment Canada, Burlington, ON, L7R 4A6; [3]Natural and Applied Sciences (Statistics), University of Wisconsin-Green Bay, Green Bay, WI, 54311. **Long-term Nutrient Trends for Lake Ontario.**

Based on data collected over the past 4 decades, trends of major nutrients are developed for Lake Ontario. Trends are developed for both total nutrients as well as major species for phosphorus, nitrogen and silica. Simple mass balance models are employed to relate the observed trends with changes in loading rates (mass per time) over the same period. The results indicate that phosphorus has declined significantly, whereas nitrogen and silica have both increased. Along with documenting the impact of the 1978 Great Lakes Water Quality Agreement on offshore conditions, the results also illustrate why controlling both phosphorus and nitrogen would have been a serious mistake. This conclusion is based primarily on the fact that the system has become increasingly phosphorus limited as documented by increasing nitrogen to phosphorus and silica to phosphorus ratios. This implies that any funds expended for nitrogen (or silica) reduction would have been unnecessary to achieve eutrophication control. *Keywords: Eutrophication, Nutrients, Lake Ontario.*

CHEN, W.C. and CHERKAUER, K.A., 225 South University Street, West Lafayette, IN, 47907-2093. **The effect of change wind speed on hydrologic process by using VIC model.**

Wind speed and direction are important factors for many physical processes, including evaporation and circulation in lakes and transpiration from plants. Nevertheless, many climate change impact assessments employ projected temperature and precipitation data to drive a hydrologic model, but do not use projections of wind, instead using constant wind velocities or historic wind observations. The general objectives of this study were to generate projected wind speed data for Midwest area and to investigate the effect of projected future wind speed on hydrologic process within the drainage area. Three-hourly wind speed, precipitation and air temperature from the North American Regional Reanalysis (NARR) dataset were rescaled to represent future climate conditions using future climate scenarios from the Geophysical Fluid Dynamics Laboratory (GFDL) global circulation model. Projected future wind speeds of period 2030-2039 were evaluated against the original NARR period 2001-2010 to quantify monthly changes in wind speeds. Finally a factor separation analysis was conducted using the Variable Infiltration Capacity (VIC) hydrology model, to evaluate the potential impact change in wind speed, precipitation, and air temperature had on hydrologic metrics including evapotranspiration.
Keywords: Climate change, Wind speed.

CHERKAUER, K.A.[1], CHEN, W.C.[1], AHMED, S.[2], TROY, C.D.[2], and HÖÖK, T.O.[3], [1]225 South University Street, West Lafayette, IN, 47907-2093; [2]550 Stadium Mall Drive, West Lafayette, IN, 47907-2051; [3]715 West State Street, West Lafayette, IN, 47907-2061. **Analysis of the impact of bias correction of NARR data on simulations of Lake Michigan.**

The impact of projected climate change on Lake Michigan fisheries is not well understood. Our project involves investigating how future climate may affect near-shore Lake Michigan fisheries habitat. For this project, we used the 3D SUNTANS hydrodynamic model to simulate lake water temperatures, which were used as input for a fish growth rate potential (GRP) model. SUNTANS requires inputs of air temperature, solar radiation, wind speed, air humidity, and surface pressure. As an initial step, North American Regional Reanalysis (NARR) data were downscaled to the SUNTANS spatial resolution. However, when compared with observational data, including buoy measurements, the downscaled NARR data had significant bias in air temperature and solar radiation. NARR does not account for the impacts of large water bodies like the Great Lakes, which likely contribute to the observed biases. Here we present the application of a bias correction method designed to improve NARR variables over the Great Lakes, and the corresponding effects on simulated lake temperatures. *Keywords: Climate change, Near-shore, Lake Michigan, NARR, Fisheries, Bias correction.*

CHIANDET, A.S. and SHERMAN, R.K., 67 Fourth st., Midland, ON, L4R 3S9. **Internal phosphorus loading and metalimnetic algae blooms: case study of an isolated embayment of South-Eastern Georgian Bay.**

North Bay is a small enclosed bay in South-Eastern Georgian Bay. Unlike some other isolated bays along the coast, it supports minimal cyanobacteria populations. However, it has a history of meta- and hypolimnetic oxygen depletion that coincides with a yearly bloom of Chrysosphaerella. Ice-free period euphotic zone samples taken since 1981 show that P has not changed, despite significant reductions in water clarity that may relate to increases in algal biovolume in recent years. Samples from 1 m off bottom show high levels of Fe and P during the stratified period. During the stratified period in 2011-12, samples taken at discrete depths (corresponding to the peak in chlorophyll a as determined by a Fluoroprobe, and 1 m above and below the thermocline) showed that, coincidental with the onset of stratification and subsequent oxygen depletion, P concentrations at 1 m off bottom increased compared to epi- meta- and upper hypolimnion levels. P levels just below the thermocline were slightly lower than epilimnion concentrations. This indicates a lack of mixing within the hypolimnion, and may signify that strong chemical gradients are present within a narrower zone above the sediment-water interface than was previously thought. Internal loading in North Bay may be overestimated, a possibility with implications for lake management. *Keywords: Algae, Internal loading, Phosphorus.*

CHISLOCK, M.F.[1], LEMAY, K.G.[2], and WILSON, A.E.[1], [1]Auburn University - Department of Fisheries and Allied Aquacultures, 203 Swingle Hall, Auburn, AL, 36849; [2]Center for Coastal Studies, Texas A&M University - Corpus Christi, Corpus Christi, TX, 78412. **Ecological Stoichiometry and the Control of Harmful Cyanobacterial Blooms: an Empirical Test of a Well-Established Tenet.**

Ecological stoichiometry examines how the nutrient content of organisms and their environment may mediate population-, community-, and ecosystem-level processes. In freshwater ecosystems, total nitrogen-to-phosphorus (N:P) ratio is considered an important mechanism structuring phytoplankton communities. The current paradigm suggests that N-fixing cyanobacteria should dominate under low N:P (<64:1, by atoms) but are outcompeted by non-N fixing phytoplankton under higher N:P. Using limnocorrals installed in a eutrophic lake (ambient N:P = 40:1) with a diverse phytoplankton community, we tested this hypothesis. At the start of the experiment, we randomly assigned limnocorrals among the ambient (40:1) and low (7:1) or high (122:1) N:P treatments, which were established by adding P or N at the start of the experiment, respectively (n = 4 replicates/treatment). In contrast to predictions, the phytoplankton community in all N:P treatments was almost entirely comprised by the N-fixing cyanobacterium, *Cylindrospermopsis*. Dominance by *Cylindrospermopsis* under such extreme N:P shows that short-term management of nutrient stoichiometry is not likely to be effective for controlling blooms of this noxious cyanobacterium and may help to explain the rapid expansion of this invasive species to temperate latitudes. *Keywords: Phytoplankton, Eutrophication, Phosphorus.*

CHOI, J.M.[1], TROY, C.D.[1], and HAWLEY, N.[2], [1]School of Civil Engineering, Purdue University, 550 Stadium Mall Drive, West Lafayette, IN, 47907; [2]NOAA Great Lakes Environmental Research Laboratory (GLERL), 4840 S. State Road, Ann Arbor, MI, 48108.
Horizontal shear flow dispersion induced by internal Poincaré waves.

The horizontal spread of substances in large lakes and oceans is important, and the reliable forecasting of dispersion patterns has received great attention. While classical theories provide predictions of diffusion and dispersion processes over small length scales for idealized scenarios, the linkages between observed dispersion rates and specific physical processes remain poorly understood. In this work we focus on the horizontal spreading of substances in the mixed layer during the summer period in Lake Michigan, examining the role of energetic internal Poincaré waves in lateral dispersion dispersion. The strong vertical shear induced by Poincaré waves is hypothesized to cause elevated dispersion in the mixed layer through a vertical shear flow dispersion mechanism. The dispersion calculated by analytical solutions simulating the idealized near inertial Poincaré wave is compared with the results from a particle tracking method. The particle tracking method is applied to both idealized velocity profiles as well as ADCP data measured in the center of Lake Michigan. The contribution of vertical turbulent mixing to the shear flow dispersion is examined by considering vertical mixing parameterizations such as Mellor-Yamada 2.5 (MY2.5), k-ε turbulent model, and K profile parameterization (KPP). *Keywords: Lake Michigan, Internal Poincaré waves, Lateral dispersion.*

CHOW-FRASER, P., 1280 Main St. West, Life Sciences Building 224, Hamilton, ON, L8S 4K1.
Settlers of Catan strategies applied to Grad School: a bit of luck and a whole lot of planning.

To the 20-somethings in my lab, playing Settlers of Catan is as much a part of field sampling as is wearing leaky waders. I will show that the winning strategy in both Catan and Grad School is similar. In the game, players choose where to settle to maximize their chance in getting resources (brick, lumber, wool, ore, and grain). In Grad School, the bricks are the things that students do in the lab (designing the sampling program and processing samples) while lumber represent field work. Wool equates to conference attendance, ore the grants needed to carry out further research, and last, but certainly not least, grain the many beers/single malts shared with mentors and colleagues. It is important to recognize that grain (beer) figures prominently in the process to publish a paper (i.e. creating a settlement), completing the thesis (building a city), and in landing a job (i.e. buying a development card). In Catan, as in Grad School, location of the first settlements gives you a head start, but strategic trading (networking) is key to getting ahead and buying those development cards that may boost your fortune. In both cases, there is no guarantee that being in a good spot will allow you to win if luck does not go your way. *Keywords: Education.*

CHOW-FRASER, P. and FRACZ, A., 1280 Main St. West, Life Sciences Building 224, Hamilton, On, L8S 4K1. **Assessing the trophic status of sheltered embayments in eastern Georgian Bay along a gradient of cottage development and morphometric characteristics.**

Recent episodes of nuisance algal growth, hypolimnetic oxygen depletion and proliferation of benthic algae occurring in late summer have been reported in a few embayments of eastern Georgian Bay. Increased phosphorus loading has been implicated in all cases but little research has been conducted to identify the factors directly responsible. Factors include Increased cottage and marina development, change in runoff from the watershed and extreme weather events, benthification of the food web by dreissenid colonization, and lack of water exchange between the bay and open waters of Georgian Bay due to low water levels. Landscape and morphometric features can also influence how a particular bay will respond to these recent environmental changes. We assembled data from various sources to regress water-quality parameters against shoreline length, number of docks and buildings, and maximum depth for 10 embayments. We found significant negative relationships between phosphorus and chlorophyll with maximum depth and a significant positive relationship between nutrients and suspended solids with number of buildings and docks. We suggest that both morphometric characteristics and human activities influence the trophic status of embayments in this region.
Keywords: Coastal ecosystems, Anaerobic conditions, Nutrients.

CHOWDHURY, M., WELLS, M.G., and COSSU, R., University of Toronto Scarborough, 1265 Military Trail, Toronto, ON, M1C 1A4. **Characterization of episodic internal turbulent mixing in the stratified waters of Lakes Simcoe, ON, Canada.**

Vertical fluxes of nutrients and dissolved oxygen in stratified lakes are driven by intermittent turbulence, and as such are hard to characterize. We present observations describing internal turbulent mixing in the stratified waters of Lake Simcoe. We will show how these episodic mixing events exhibited strong correlation with the environmental variability in air temperatures and wind forcing. The observations are made from high-frequency water column thermal stratification measurements by a chain of thermistors, along-beam velocity measurements by an Acoustic Doppler Current Profiler (ADCP). We quantified the turbulent mixing rates by processing the trubulence statistics of the ADCP data and by calculating the frequency of temperature inversions, from very high frequency and high precision water temperature measurements on a mooring. The estimates of both methods agreed reasonably well when there was strong mixing in the water column. The strongest turbulence and internal mixing events occurred in the epilimnion of Lake Simcoe when gradient Richardson number, $Ri_g < 1$ and wind speed, $u_W > 8$ m/s. The thermocline acted as a barrier for the turbulence and mixing in the hypolimnion even for u_W 10 m/s for most of the duration, except for the few intermittent events (less than 3% of the deployment). *Keywords: Coastal processes, Lake Simcoe.*

CHRISCINSKE, M.A., DAVIS, B.M., and BUNNELL, D.B., USGS - Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105. **Evaluating Changes in Lake Michigan Prey Fish Diets in Response to Food Web Changes in the Late 1990s and Early 2000s.**

The Lake Michigan offshore food web has changed dramatically in recent years, influenced by a wave of successful aquatic invaders such as dreissenids, *Bythotrephes*, and round gobies. In particular, there have been substantial changes in the composition of fish and zooplankton populations. Proliferation of dreissenids is considered a causal mechanism in the decline of the benthic amphipod *Diporeia*, thereby affecting the diets of forage fish species which have historically relied upon it as a major diet item. We examined the diets of bloaters, rainbow smelt, alewives, and slimy and deepwater sculpins, captured from depths of 18 m to 110 m from two ports in northern Lake Michigan in April, July, and September 2010. These were compared to diets of these same species taken from northern Lake Michigan in 1994-95. Whereas in the 1990s *Diporeia* was a major diet item for primarily benthic species like bloaters and sculpins, it has been replaced by *Mysis* in 2010. *Diporeia* were also important in the diet of alewives in the 1990s, but were not in 2010. Round goby ate a mix of benthic prey, with a peak in dreissenid consumption in summer. Not only did diet composition of the prey fish change between the 1990s and 2000s, but the total biomass of prey consumed also declined markedly for all species. *Keywords: Fish diets, Lake Michigan, Invasive species.*

CIBOROWSKI, J.J.H.[1], KOVALENKO, K.E.[1], AXLER, R.P.[2], BRADY, V.J.[2], BROWN, T.N.[2], DANZ, N.P.[3], GATHMAN, J.P.[4], HOST, G.E.[2], HOWE, R.W.[5], JOHNSON, L.B.[2], NIEMI, G.J.[2], and REAVIE, E.D.[6], [1]Department of Biological Sciences,, University of Windsor,, Windsor,, ON, N9J 3P4; [2]Natural Resources Research Institute, University of Minnesota Duluth, , Duluth, MN, 55811; [3]Department of Natural Sciences, University of Wisconsin Superior, Superior, WI, 54880; [4]Department of Biology, University of Wisconsin River Falls, River Falls, WI, 54022; [5]5Department of Natural & Applied Sciences, University of Wisconsin Green Bay, Green bay, WI, 54311; [6]Ely Field Station, University of Minnesota Duluth, Ely, MN, 54311. **Bioindicator Sensitivity and Consistency of Classification - Comparing Among Methods and Taxa at Great Lakes Coastal Margins.**

Increasing interest in bioassessment stimulated development of biological and environmental indicators derived by various methods and using different component variables. Their common purpose is to evaluate and ultimately classify areas as 'acceptable' or 'unacceptable'. Yet, no common criterion exists for evaluating individual indicators' effectiveness and sensitivity, or for comparing the behaviour of different indicators to one another. We propose the following common framework: a) divide the disturbance gradient (X-axis; a 'reference-degraded continuum (RDC)) characterising a study system into 3 classes of environmental condition (reference, degraded, and 'neither') according to some acceptable criterion; b) define two fixed points along the continuum as reference/nonreference and nondegraded/ degraded boundaries; c) evaluate test sites' environmental attributes to determine their position along the RDC ('true' condition); d) use values of a candidate bioindicator (dependent variable) to classify each test site (its 'inferred' condition); e) assess the goodness of

fit (concordance) between the true and inferred condition of sites assigned to the three condition classes. *Keywords: Bioindicators, Biomonitoring, Great Lakes basin.*

CLAPP, D.F., Michigan DNR Fisheries Division, 96 Grant Street, Charlevoix, MI, 49720.

Research and Adaptive Management of Great Lakes Yellow Perch Populations.

Catch of Lake Michigan yellow perch declined dramatically between 1988 and 1998, and the population age structure shifted toward older fish due to an almost complete lack of recruitment. A multi-agency Yellow Perch Task Group was formed in 1994 to address this decline. The Task Group initially developed a prioritized list of 17 possible hypotheses for the lack of perch recruitment, and pursued funding to conduct research addressing these hypotheses. Research efforts involved contributions from federal, state, and university interests both within and outside the basin. Hypotheses receiving the most attention involved factors related to pre-demersal survival of yellow perch; including egg stage and spawning stock influences, diet limitations, and possible predation effects. Spawning stock diversity, diet, and predation probably act in concert, along with harvest and other factors, to regulate yellow perch abundance. Progress achieved in investigating these factors served to sharpen the focus of the Task Group, and demonstrated that a research and management strategy coordinated across lakes and scientific disciplines improved our understanding and management success with respect to Great Lake's yellow perch populations. *Keywords: Yellow perch, Fish management, Lake Michigan.*

CLARK, R.D., Quantitative Fisheries Center, 293 Farm Lane, East Lansing, MI, 48824. **Is our traditional single-lake management approach sufficient to ensure salmonine sustainability in the Great Lakes?**

Management of fishes in the Great Lakes is coordinated within individual lakes by committees of the Great Lakes Fishery Commission. In addition, research results and management case studies are shared across lakes at joint committee meetings and in published reports. However, management coordination across lakes is rare. Even within multi-lake states like Michigan, management is organized by individual lake basin. I suggest our single-lake management approach might be insufficient for some species. For example, evidence suggests movement of adult Chinook salmon from Lake Huron to Lake Michigan has been increasing in recent years. Single-lake management models currently in use treat Chinook salmon as having two non-interacting populations within each lake. But if movement between lakes is significant, then reliance on these models could lead to errors in stocking and other management decisions. I argue that across-lake management coordination should be adopted for Chinook salmon in lakes Michigan and Huron and probably should be considered for other species and other lakes. For example, steelhead, walleye, whitefish, and lake sturgeon all have the potential to make significant movements between lakes. *Keywords: Fish management, Fish populations, Salmon.*

CLITES, A.[1], KRAMER, E.L.[2], FRY, L.M.[2], ANDERSON, E.J.[1], and GRONEWOLD, A.D.[1], [1]NOAA Great Lakes Environmental Research Lab, 4840 S. State Rd, Ann Arbor, MI, 48108, United States; [2]Cooperative Institute for Limnology and Ecosystems Research, 4840 S. State Rd, Ann Arbor, MI, 48108. **Implications of an Improved Hydrologic Model for Understanding Near Shore Hydrodynamics: Impacts of the Clinton River Spillway on Predicting Beach Water Quality.**

A linked hydrologic-hydrodynamic model of the Clinton River is being verified for use as a predictive beach water quality model. The Clinton River, a river with an urban and agricultural watershed, flows into Lake St. Clair near one of the most heavily used public beaches in the Detroit metropolitan area. A spillway channel was constructed upstream of the City of Mt. Clemens in the 1950's to relieve flooding. The objective of this study was to determine the flow split and variability in that split under different flow conditions between the natural Clinton River channel and the spillway to improve the beach water quality model. To address this need, we developed a model using discharge observations from both the natural channel and the spillway mouth. A relationship was established between observed upstream discharge and the fractional split between the channel and the spillway, accounting for influences of Lake St. Clair water levels on backwater effects at the spillway and channel mouth gages. We assessed the impact of alternative flow scenarios on nearshore water quality, and found that correctly representing the split has lead to a considerably improved understanding of the Clinton River watershed's impacts on the near shore ecosystem. *Keywords: Hydrodynamics, Hydrologic model, Beach water quality forecast.*

CLOUTIER, D.D. and MCLELLAN, S.L., 600 E. Greenfield Ave, Milwaukee, WI, 53204.
Effect of the Indigenous Microbial Community on the Persistence of Fecal Indicators in Lake Michigan Beach Sand.

E. coli and *enterococci* are the most commonly used indicators of fecal pollution. It has been determined that these indicators are capable of persisting in the beach environment, however, the mechanism by which this occurs is poorly understood. We suggest pristine beaches favor increased indicator die-off compared to frequently contaminated urban beaches. Microcosms were used to test the effect of biotic stress on the survival of *E. coli* and *E. faecalis*. We compared die-off rates in natural and sterile sand inoculated with *E. coli* and *E. faecalis*. Sterile sand microcosms exhibited 3-fold and 2-fold higher plate counts of *E. coli* and *E. faecalis*, respectively. The natural microcosms failed to show the same increases in fecal indicators, suggesting predation and/or competition by the native community could be affecting die-off. Stronger die-off for both indicators was observed in the pristine beach compared to the urban beach. Sequencing the V4/V6 region of the 16S rRNA gene revealed the beaches contained distinctive communities, compounding evidence for microbial antagonism. Since recreational beach pollution negatively impacts public and economic health, investigating biotic stress as a regulator of indicator persistence will lead to a better understanding of beach health.
Keywords: Environmental health, Bioindicators, Microbiological studies.

COLE, K.M.[1], GALAROWICZ, T.L.[1], CLARAMUNT, R.M.[2], CHADDERTON, W.L.[3], HERBERT, M.E.[3], and O'NEILL, P.J.[2], [1]Central Michigan University, Brooks 217, Mount Pleasant, MI, 48859; [2]Michigan Department of Natural Resources, 96 Grant Street, Charlevoix, MI, 49720; [3]The Nature Conservancy, 101 East Grand River Avenue, Lansing, MI, 48906.
Offshore Movement of the Invasive Round Goby (*Neogobius melanostomus*) in Northern Lake Michigan.

Round goby (*Neogobius melanostomus*) abundances are continuing to increase in the Great Lakes, especially throughout Lake Michigan. There are limited data regarding round goby movement, with no studies examining round goby seasonal movement as well as use of interstitial habitats. The goal of this study was to determine the changes in round goby seasonal movement and distribution in northern Lake Michigan. Specifically, the objectives were to (1) determine if and how round goby abundance varies temporally and by depth, and (2) quantify changes of round goby interstitial distribution. To determine temporal and spatial changes in round goby abundance, round gobies were sampled on six rocky reefs between July and December using standard minnow traps, buried egg bags, and underwater cameras. Round goby densities increased through the fall on the reefs, but then they tended to move offshore as temperatures slowly decreased. However, a portion of the round goby population remained on the reefs but moved deeper into the substrate as temperatures decreased. These findings will help fisheries managers better understand seasonal abundance shifts in order to develop effective management strategies targeting round gobies and other invasive species. *Keywords: Round goby, Seasonal movement, Lake Michigan.*

COLLINGSWORTH, P.C.[1] and WARREN, G.J.[2], [1]Purdue University, 77 W. Jackson Blvd, Chicago, IL, 60604; [2]U.S.E.P.A. Great Lakes National Program Office, 77 W. Jackson Blvd, Chicago, IL. **Impacts of Local and Basin-Scale Factors on the Relationship Between Total Phosphorus and Chlorophyll in Lake Erie.**

Phosphorus is commonly cited as the limiting nutrient for algal production in freshwater systems. However, attempts to describe the relationship between total phosphorus (TP) and chlorophyll in lakes are routinely confounded by external factors at various scales. Here, we present model results describing the relationship between TP and chlorophyll in Lake Erie that accounts for variation at the lake, basin and local scales. We found a strong positive relationship between TP and chlorophyll during the summer and variation in this relationship was influenced by both basin and local-scale factors. At the basin scale, the model tended to under predict chlorophyll concentrations in the central and eastern basins, but over predicted in the western basin. Locally, variation in the TP-chlorophyll relationship was influence by the depth of the sampling site, with more accurate predictions of chlorophyll occurring at deep, offshore sites and poor model performance at shallow sites. Our results suggest that modeling efforts to describe TP-chlorophyll dynamics in the Great Lakes need to address variation at multiple scales, such as basin-level TP loading and local site depth and inorganic turbidity. *Keywords: Monitoring, Phosphorus, Phytoplankton.*

CONFESOR, R.B.[1], RICHARDS, R.P.[1], and MCELMURRY, S.P.[2], [1]NCWQR, Heidelberg University, 310 E. Market St., Tiffin, OH, 44883; [2]Dept. of Civil and Env Eng, Wayne State University, 5050 Anthony Wayne Dr., Detroit, MI, 48202. **A review of agricultural BMPs in reducing total phosphorus and dissolved reactive phosphorus loads to Lake Erie.**

Under its Lake Erie Ecosystem Priority, the International Joint Commission charged a work group to review the effectiveness of agricultural and urban BMPs in reducing total phosphorus (TP) and dissolved reactive phosphorus (DRP) loads to Lake Erie. This presentation focuses on agricultural BMPs. Among our findings are: 1) Most studies were done outside of the Lake Erie watershed and rigorous assessment of BMP effectiveness specific to Lake Erie is lacking; 2) Most BMP assessments were focused on TP and sediment reduction, but increased DRP loading is a major problem for Lake Erie; 3) Estimates of effectiveness vary greatly, and results from different studies are often conflicting; 4) Assessments were done at different scales (plot, field, and watershed) and were either field studies or simulation modeling; 5) Assessment of individual BMP effectiveness is complicated because BMPs are usually implemented in combination with other BMPs; 6) There is no simple solution to non-point source nutrient pollution, particularly DRP, and the use of suites of BMP is recommended; 7) Soil-P stratification and tradeoffs in controlling DRP vs. sediments are additional challenges; 8) An inventory of implemented agricultural BMPs in Lake Erie watersheds is needed; 9) BMP cost-effectiveness must be considered in future studies. *Keywords: Agriculture, Nutrients, Effectiveness, Lake Erie, Best management practice, Phosphorus.*

COOPER, M.J.[1], LAMBERTI, G.A.[1], and UZARSKI, D.G.[2], [1]Department of Biological Sciences, University of Notre Dame, Notre Dame, IN, 46556; [2]Institute for Great Lakes Research, Central Michigan University, Mount Pleasant, MI, 48858. **Abiotic Drivers and Temporal Variability of Saginaw Bay Wetland Invertebrate Communities.**

The shallow-sloping coastal bathymetry of Saginaw Bay supports broad fringing marshes. Benthic invertebrates form an important forage base for fish, wading birds, and waterfowl that utilize these wetlands so understanding the drivers of invertebrate community structure has significant management implications. We used Great Lakes Basin-wide data to put Saginaw Bay wetland invertebrate communities and their environmental drivers into a basin-wide context. Effective fetch and watershed percent agriculture were highly correlated with various aspects of community structure across the basin and Saginaw Bay wetlands were unique because they had relatively high effective fetch and watershed agriculture. Ordination and classification analyses revealed that Saginaw Bay wetland invertebrate communities were also unique, having relatively high proportions of many insect taxa. A 1997-2012 time series from three representative Saginaw Bay wetlands revealed substantial shifts in community structure in the years immediately following the 1-m water level decline in Lake Huron that occurred between 1997 and 2000. Our results demonstrate the unique structure and marked temporal dynamics of Saginaw Bay wetland invertebrate communities. *Keywords: Benthos, Coastal wetlands, Lake Huron.*

CORCORAN, M.[1], STURCHIO, N.C.[1], POGHOSYAN, A.[1], LI, A.[1], ROCKNE, K.J.[1], and GIESY, J.P.[2], [1]University of Illinois at Chicago, 845 W. Taylor, Chicago, IL, 60607; [2]University Of Saskatchewan, Dept. of Veterinary Biomedical Sciences and Toxicology Centre, Saskatoon, SK, S7N 5B3. **Sedimentation Rates in Lake Michigan Using ^{210}Pb, ^{137}Cs, and ^{241}Am.**

Lake sediments can preserve a temporal record of contaminant deposition. Short-lived radionuclides ^{210}Pb and ^{137}Cs in lake sediment cores are used in combination for dating recent (150 years BP) sediments to determine sedimentation rates and dates of contaminant deposition. However, ^{137}Cs has been shown to be mobile in some lake sediments with high porosity making it potentially unreliable. Ten sediment cores were collected in 2010 and 2011 from Lake Michigan and analyzed by gamma spectrometry for ^{210}Pb, ^{137}Cs, ^{226}Ra, and ^{241}Am. Average porosities for the cores range from 82.1% to 94.5%. Sedimentation rates using ^{210}Pb are 0.011 to 0.066 g/cm^2/year, within the range of other studies of Lake Michigan. Total inventories at nine sites are 1.64 to 3.00 times expected values from atmospheric deposition (the "focus factor") for ^{210}Pb and 1.19 to 3.25 times expected values for ^{137}Cs. The ^{241}Am profiles generally show a peak close to the ^{137}Cs profile peak. The ^{241}Am profiles are consistent with those of ^{137}Cs, indicating limited postdepositional mobility of these nuclides. *Keywords: Sediments, Dating, Lake Michigan, Radioisotopes.*

CORNWELL, E.R.[1], GOYETTE, J.O.[2], and SORICHETTI, R.J.[3], [1]Cornell University College of Veterinary Medicine, Department of Microbiology and Immunology, Ithaca, NY, 14850, [2]Université de Montréal, Département de Sciences Biologiques, Montréal, QC, H2V 2S9; [3]Western University, Department of Biology, London, ON, N6A 5B7. **Biological and Chemical Contaminants in the Great Lakes-St. Lawrence River Basin.**

Many initiatives since the early 1900s have been implemented to maintain water quality within the Great Lakes-St. Lawrence River Basin. Despite these substantial efforts, emerging and re-emerging biological and chemical contaminants continue to pose serious human, animal and ecosystem health risks. With over 100 biological and chemical contaminants detected in the Basin and over 600 persistent and bio-accumulative contaminants listed on international databases, the threat of these contaminants on the Basin is immense. This paper discusses legacy and emerging contaminants, as well as contaminants of mutual concern and their interactions within the Basin. A 50 year history of these contaminants has been prepared as well as a synthesis of their current state. From this information, three future scenarios for contaminants have been prepared for the next 50 years and they are termed The Good, The Bad and The Ugly. As many drivers of ecosystem change impact the Basin, in addition to contaminants, this paper elaborates on the interaction between contaminants and additional drivers of change. By exploring the plausible future scenarios of contaminants in the Great Lakes-St. Lawrence River Basin, we aim to highlight the need for bi-national agreements and initiatives to restore and protect the Basin and encourage ecosystem health. *Keywords: Toxic substances, Contaminant, Organic compounds, Great Lakes, Eutrophication, Pathogen.*

CORTES, A.[1] and WELLS, M.G.[2], [1]Universidad de Granada, C/Ramón y Cajal, 4, Granada, 18071, Spain; [2]University of Toronto, 1265 Military Trail, Toronto, ON, M1C 1A4.
Observations and modelling of river intrusions into a stratified reservoir.

Negatively buoyant inflows entering a reservoir will plunge and flow downward along the bottom as a density current. When the density current reaches the level of neutral buoyancy it can separate from the boundary and form an intrusion. Recent laboratory experiments suggest that a significant fraction of inflow water entering stratified bodies might be distributed throughout the water column rather than forming a single discrete intrusion. We discuss results from a series of laboratory experiments, that are motivated by a series of tracer release experiments conducted in a stratified reservoir in Spain. Given a density distribution in a gravity current, we show what percentage of the current will intrude into the base of the surface mixed layer, and what percentage will intrude at depth in a reservoir. *Keywords: Water currents, Hydrodynamics.*

COULTER, A.A.[1] and GOFORTH, R.R.[2], [1]Purdue University, 715 W. State St., G-021, West Lafayette, IN, 47906; [2]Purdue University, 715 W. State St., West Lafayette, IN, 47906.
Patterns in Silver Carp (Hypophthalmichthys molitrix) Movements in a Large River.

Bigheaded carps continue to rapidly spread throughout the Mississippi River Basin. Using data collected from 2011-2012, we have investigated variables thought to influence the movements of Silver Carp (*Hypophthalmichthys molitrix*) in the Wabash River, Indiana. Movement data were collected through an acoustic telemetry study involving 162 individuals monitored through both active and stationary tracking. Movements were examined in relation to time, sex, temperature and flow. We expect this information to be useful to both managers and those attempting to model bigheaded carp expansion in novel ecosystems. *Keywords: Biological invasions, Telemetry, Carp, Invasive species.*

COULTER, D.P.[1], SEPULVEDA, M.S.[1], TROY, C.D.[2], and HÖÖK, T.O.[1], [1]Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN, 47907; [2]School of Civil Engineering, Purdue University, West Lafayette, IN, 47907. **Temperature Variability in the Great Lakes: Impacts on Fish Growth, Survival, and Egg Hatching Success.**

Many Great Lakes fishes experience environments with frequent temperature fluctuations. Moreover, current temperature variability may be further enhanced with climate change. To explore how this can affect Great Lakes fishes, we first analyzed water temperature data to document the magnitude and duration of temperature fluctuations throughout the region. Shallow wetlands, for example, displayed minor diel temperature changes whereas nearshore habitats in southern Lake Michigan experienced severe, sub-daily fluctuations. To understand the effects of temperature variation on fish growth and survival, we conducted laboratory experiments exposing adult yellow perch and age-0 walleye to one of three treatments: a constant temperature, and fluctuations of either ±2°C or ±4°C. Neither species showed differences in survival, however extreme fluctuations resulted in increased growth rates for perch and

decreased growth rates in walleye. In order to understand how early life stages are affected by temperature variation, we also exposed fathead minnow eggs to these treatments and compared egg hatching success and incubation time. Understanding how fish respond to temperature variation is important since growth rates and hatching success ultimately affect population-level attributes including size distributions and recruitment success. *Keywords: Climatic data, Bioenergetics, Coastal ecosystems.*

COWEN, E.A. and SCHWEITZER, S.A., DeFrees Hydraulics Laboratory, School of Civil & Environmental Engineering, Cornell University, Ithaca, NY, 14853-3501. **How an Invasive Bivalve Potentially Led to Increased Chlorophyll-a Levels in a Large Lake: A Modeling Study Supported by Extensive Field Data.**

Cayuga Lake is a long (65km), narrow (3km) and deep (130m) lake located in the Finger Lakes region of New York. The invasive quagga mussel *Dreisena bugensis* was observed in the lake starting around 2005. Subsequently mean summer chlorophyll-a concentrations rose 60%, from 5.2 ug/L to 8.5 ug/L. Phosphorus in the lake's hypolimnion increased as well, annual mean SRP increased nearly 80% from 4.8 ug/L to 8.6 ug/L. Similar trends have been observed in the neighboring and similarly sized Seneca Lake, suggestive of a regional trend. We hypothesize that the increase in hypolimnetic SRP is a result of the colonization of the lake by quagga mussels and that vertical entrainment of phosphorus into the surface mixed layer is the cause of increased concentrations of chlorophyll-a. Using the open source GLM-FABM (General Lake Model - Framework for Aquatic Biogeochemical Models) model, supported by a decade of field observations in Cayuga Lake, we capture the vertical processes to test our hypothesis. While we lack data on mussel density, we estimate the biological forcing required to produce the observed trends in nutrients and chlorophyll-a. We use an existing data set with the same model to explore the potential impact of quagga mussels on Seneca Lake and if they might explain recent nutrient and chlorophyll-a trends there as well. *Keywords: Hydrodynamic model, Algae, Nutrients, Mussels.*

CREQUE, S.M.[1], DETTMERS, J.M.[2], CZESNY, S.J.[1], and REDMAN, R.A.[1], [1]INHS, Lake Michigan Biological Station, 400 17th St, Zion, IL, 60099; [2]Great Lakes Fishery Commission, 2100 Commonwealth Blvd, Ste 100, Ann Arbor, MI, 48105. **Sport fish use of an artificial reef in nearshore Lake Michigan during 2000-2006.**

In November 1999, an artificial reef composed of granite rubble was built in southwestern Lake Michigan near Chicago to attract smallmouth bass and create angler opportunities. Adult fish communities were sampled at the artificial reef site and a nearby reference site before (1999) and after reef construction (2000-2006) via 180 total gill nets sets and 76 SCUBA dive transects. Total number of fish and species diversity observed during SCUBA dive transects was higher at the artificial reef than at the reference site during 2000-2006. Both dive and gill net data showed higher numbers of smallmouth bass and rock bass at the reef compared to the reference area. However, mean annual total gill net CPUE did not differ at the two sites after reef construction indicating the reef only attracted species that prefer rocky, complex habitats. For example, freshwater drum and salmonines exhibited clear responses to temperature rather than site specific preferences. Although anglers were aware of the artificial reef, fishing effort and success were low, in part because few anglers targeted bass. In addition to attracting desirable sport fish, the Lake Michigan artificial reef also attracted large numbers of invasive round goby. The structure of the artificial reef has remained intact and not buried as of summer 2012. *Keywords: Habitats, Smallmouth bass, Lake Michigan, Fishing.*

CREQUE, S.M.[1], CHICK, J.H.[2], and CZESNY, S.J.[1], [1]Lake Michigan Biological Station, Illinois Natural History Survey, Univ. IL., Zion, IL, 60099; [2]National Great Rivers Research & Education Center, Illinois Natural History Survey, Univ. IL, East Alton, IL, 62024. **Rotifer abundance and composition in Lake Michigan: a significant data gap in understanding the potential for the establishment of Asian carp populations.**

Invasive silver and bighead carp (collectively referred to as Asian carp) have developed large populations in the Mississippi and Illinois rivers. There is a significant potential for the introduction of these invasive species to the Great Lakes through the Chicago Sanitary and Shipping Canal and other vectors. Recent assessments of phytoplankton and zooplankton abundance in Lake Michigan led to the general conclusion that only the most productive areas, such as Green Bay, river mouths, and large harbors, had sufficient food resources to support Asian carp growth. However, these studies only assessed the crustacean portion of zooplankton communities because accurate information on rotifer abundance was not available. Recent studies of Asian carp and zooplankton in the Mississippi River have shown that rotifers are an important prey item for Asian carp, and that mesh sizes typically used in zooplankton sampling (e.g., ≥ 63 µm) are too large to adequately assess rotifer abundance. We sampled the near-shore area of Lake Michigan using both a standard 63-µm mesh plankton net and whole water samples filtered through 20-µm mesh to accurately estimate the abundance of rotifers. With these data we will re-assess the ability of the Lake Michigan plankton community to support Asian carp. *Keywords: Zooplankton, Sampling methodology, Invasive species, Carp.*

CRIMMINS, B.[1], XIA, X.[2], MILLIGAN, M.S.[3], PAGANO, J.[4], HOPKE, P.[2], and HOLSEN, T.M.[1], [1]Clarkson University, Potsdam, NY, 13699; [2]Clarkson University, Potsdam, NY, 13699; [3]SUNY Fredonia, Fredonia, NY, 14063; [4]SUNY Oswego, Oswego, NY, 13126. **Atmospheric Pressure Gas Chromatography Quadrupole Mass Spectrometry: Emerging Contaminant Screening in Great Lakes Trout.**

Currently, Great Lakes studies are proactively searching for undiscovered harmful compounds in various aquatic media. New techniques employing multi-dimensional chromatography (GCxGC) and high resolution mass spectrometry promise to rapidly increase our understanding of the chemical composition of biotic and abiotic media. Atmospheric pressure gas chromatography quadrupole time of flight mass spectrometry (APGC-QToF) is an emerging technique that holds promise to improve screening effectiveness. The soft charge transfer enabled by the N2 plasma limits fragmentation, generating a larger molecular ion response. The resulting sensitivity to a molecular ion may assist in the identification of new

chemicals of concern when coupled to a high resolution QToF detector. Sensitivity and linearity of this technique was evaluated using dioxins, furans, telomer alcohols and fatty acid. Lake trout composites were also screened for halogenated (Cl, Br, F) emerging contaminants and results from these experiments and a critique of this method relative to the GCxGC-TOF will be presented. *Keywords: Environmental contaminants, Lake trout, Mass spectrometry.*

CROFT-WHITE, M. and ST JOHN, M., Toronto and Region Conservation Authority, Toronto, ON, M3N 1S4. **Now you see it, now you don't; assessment of Degradation of Aesthetics as a Beneficial Use Impairment in the Toronto and Region Area of Concern.**

The 1989 the Toronto Remedial Action Plan (RAP) Stage 1 report, 'Environmental Conditions and Problem Definition' stated that Beneficial Use Impairment #11, Degradation of Aesthetics, was significant to the region as 'aesthetics concerns relate primarily to debris and litter. Turbidity is also a concern near river mouths and in the vicinity of lakefilling operations. Weed growth is a concern along the western shoreline'. Degradation of aesthetics was thus listed as a BUI, however little monitoring was undertaken to specifically address this BUI as it was seen as challenging to assess in a quantifiable manner. In 2012 the Toronto and Region RAP developed a quantifiable checklist for assessing the Degradation of Aesthetics in the region, technicians at the Toronto and Region Conservation Authority were trained in the assessment and hundreds of sites were sampled throughout the Area of Concern's six watersheds and along the waterfront. The results suggest that Degradation of Aesthetics is no longer a Beneficial Use Impairment for the Toronto and Region Area of Concern and should be reclassified as 'not impaired'. *Keywords: Aesthetics, Remedial Action Plan, Area of Concern.*

CYTERSKI, M.J.[1], GALVIN, M.[1], WOLFE, K.L.[1], BROOKS, W.R.[2], CORSI, S.R.[2], RODDICK, T.[2], MEDNICK, A.C.[3], and ROCKWELL, D.[4], [1]U. S. Environmental Protection Agency, Ecosystems Research Division, Athens, GA, 30605; [2]U.S. Geological Survey, Wisconsin Water Science Center, Middleton, WI, 53562; [3]Wisconsin Department of Natural Resources, 101 S Webster St, Madison, WI, 53707; [4]Cooperative Institute fo Limnology and Ecosystems Research, University of Michigan, Ann Arbor, MI, 48109-1041. **Advanced Decision-Support for Coastal Beach Health: Virtual Beach 3.0.**

Virtual Beach is a free decision-support system designed to help beach managers and researchers construct, evaluate, and operate site-specific statistical models that can predict levels of fecal indicator bacteria (FIB) based on environmental conditions that are more readily measured, estimated, or forecast. Since its first operational use in 2009, Virtual Beach has been updated several times based on feedback from users in the field. These updates have improved the efficiency of the model-building and evaluation process and made the process of operating a predictive model faster and more user-friendly. Virtual Beach 3.0 includes significant enhancements, including new statistical methods and the integration of hydro-meteorological data accessed through the Web-based Environmental Data Discovery and Transformation (EnDDaT) system. New statistical methods include partial least squares (PLS) regression and gradient boosted modeling (GBM), which provide alternatives to the standard multiple-linear regression (MLR) approach, optimized using a genetic algorithm. This poster will illustrate the functionalities of the enhanced software and highlight applications in the Great Lakes. *Keywords: Nearshore, Human health, Decision support, Beaches, Water quality.*

CZESNY, S.J.[1], RINCHARD, J.[2], HANSON, D.[3], HAPPEL, A.H.[1], and HÖÖK, T.O.[4], [1]Lake Michigan Biological Station, Illinois Natural History Survey, University of Illinois, Zion, IL, 60099; [2]The College at Brockport, State University of New-York, Brockport, NY, 14420; [3]U.S. Fish and Wildlife Service, Green Bay Fishery Resources Office, New Franken, WI, 54229; [4]Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN, 47907.
Utility of Fatty Acid Signature Analysis in Large Freshwater Food Web.

Non-indigenous species may alter trophic pathways resulting in deleterious impacts to native fish communities. To better understand the trophic structure in Lake Michigan, lipid content and fatty acid profiles of common forage species/taxa groups were determined. Spatial and temporal variability in fatty acid signatures was assessed using multivariate techniques. Body size and sampling location had significant effects on fatty acid composition, which likely related to known ontogenetic diet shifts in several species of fish. Despite various sources of variation, within-species variability was relatively small compared to among-species variability in fatty acid profiles. Thus, fatty acid signatures can be used in freshwater systems to study food web interactions and delineate spatial-temporal changes in food web structure. *Keywords: Lake Michigan.*

DAHLSTROM, A.A.[1], FUSARO, A.J.[1], and CHARLEBOIS, P.[2], [1]Wayne State University, Department of Biological Sciences, 5047 Gullen Mall, Detroit, MI, 48202, United States; [2]Illinois-Indiana Sea Grant/Illinois Natural History Survey, 1000 Lake Cook Rd, Glencoe, IL, 60022. **Expert Judgment: Setting the Scene for Use in the Great Lakes Region.**

Soliciting and integrating expert judgment can occur in a range of forms--from the consultation of a single expert to the consensus of a group of interacting experts. While expert judgment has often been used to assess risks surrounded by high uncertainty, it is increasingly used in both project design and dissemination. This presentation will highlight the theory and practice of incorporating expert engagement to maximize research outcomes, as well as provide a variety of case studies demonstrating potential applications. *Keywords: Risk assessment, Decision making, Conservation.*

DANN, S.L.[1], SCHROEDER, B.C.[2], BURROUGHS, J.[3], and RATKOS, J.[4], [1]Michigan State University, Dept. of Community, Agriculture, and Recreational Resource Studies, 147B Natural Resources, East Lansing, MI, 48824; [2]Michigan Sea Grant, Michigan State University Extension, 603 South 11th Ave, Alpena, MI, 49707; [3]Michigan State University, Department of Fisheries and Wildlife, 13 Natural Resources Building, East Lansing, MI, 48824; [4]Michigan 4-H Youth Programs, 160 Agriculture Hall, Michigan State University, East Lansing, MI, 48824. **4-H Great Lakes and Natural Resources Camp: A summer place-based learning opportunity for youth.**

Eighty teens from across Michigan study local fisheries, monitor threatened species, create a coastal wetland EarthCache for ecotourism benefit, and more - all in a week of science learning and youth leadership at Michigan 4-H Great Lakes and Natural Resources Camp. This program reflects a dynamic partnership between natural resource scientists paired with youth development experts. The goals of this Michigan State University Pre-College Program are to foster youth leadership through field-based, mentor-supported, and career-oriented connections with Great Lakes and natural resources. Pre- and post-program surveys have measured statistically significant increases in many Great Lakes literacy factors, documenting increased interest in science, readiness for college, awareness of potential careers, and environmental stewardship. Long-term evaluation efforts have focused on program impacts on teen leaders' sense of place, Great Lakes knowledge, and stewardship intentions. Science literacy has become the focus of many resource agencies, as evidenced by the Great Lakes Literacy framework (greatlakesliteracy.org). The 4-H Great Lakes and Natural Resources Camp provides a science literacy program model by which resource agencies and education interests can partner in fostering Great Lakes literacy and leadership among youth. *Keywords: Education.*

DAVIS, R.T.[1], TANK, J.L.[1], MAHL, U.H.[1], and ROLEY, S.S.[2], [1]University of Notre Dame, 188 Galvin Life Sciences, Notre Dame, IN, 46556; [2]Kellogg Biological Field Station, 3700 East Gull Lake Drive, Hickory Corners, MI, 49060. **Effect of Floodplain Construciton in Agricultural Streams on Nitrogen, Phosphorus, and Sediment Export.**

Agricultural streams have been channelized to maximize water conveyance, especially during storms and spring snowmelt. The two-stage ditch is a novel management practice which constructs floodplains alongside channelized streams, thereby increasing bank stability, improving denitrification potential, and decreasing stream water turbidity. However, potential reductions in streamwater nitrogen (N), phosphorus (P), and total suspended solids (TSS) have not been quantified. We hypothesized that floodplain restoration would decrease nitrate concentrations due to increased bioreactive surface area for denitrification during floodplain inundation. In addition, we predicted that the two-stage would decrease both soluble reactive phosphorus (SRP) and total phosphorus (TP), via increases in assimilatory demand and sediment deposition on floodplains. After 2 years of monitoring in multiple streams, we found that the two-stage decreased SRP and TP concentrations in two of four streams. In contrast, we found no change in inorganic N concentrations. In addition, in situ turbidity sensors correlated with TP for each of the four streams; correlations were strongest within individual streams. Our results suggest that the two-stage ditch potentially improves water quality but the magnitude and

consistency of that benefit varies across streams. *Keywords: Biogeochemistry, Nutrients, Eutrophication.*

DAY, J., CHIN, N., and SYDNOR, S., Purdue University, 900 State St, Rm 255, West Lafayette, IN, 47907. **Developing Resilience to Climate Change Impacts on Tourism in Great Lakes Destination Communities.**

Tourism is an important activity within the Great Lakes region providing significant economic contribution to many destination communities. Weather and climate are important destination assets (Cook, Yale, & Marqua, 2010; Thapa, 2012) and climate change is projected to impact tourism in these destinations in a number of ways, from changes in winter recreational activities (Hayhoe, VanDorn, Croley, Schlegal, & Wuebbles, 2010) over the long term to increasing numbers of significant weather events such as severe storms and heat waves (Mortsch et al., 2010) The resilience and adaptive capacity of destination communities to these impacts is a key issue in their long term sustainability. The current study uses scenario planning techniques to assess potential risks of climate change on the tourism systems in communities. The study addresses both destination community and specific enterprise responses to the risks identified. The study also proposes a place based resilience model for communities (Cutter et al 2008; Norris et al, 2008) reliant on tourism for community sustainability. *Keywords: Climate change, Tourism, Economic impact, Community development, Policy making.*

DEBRUYNE, R.L.[1], ROSEMAN, E.F.[1], CRAIG, J.[1], IRELAND, S.[1], BOUCKAERT, E.B.[2], and BENNION, D.[1], [1]USGS Great Lakes Science Center, Ann Arbor, MI; [2]Michigan Technological University, Houghton, MI. **Gradients in thermal Habitat Influence Fish Spawning Phenology.**

River spawning fishes initiate spawning in response to a multitude of factors that can vary across systems. Change in flow is a common trigger; however, in some connecting channels such as the St. Clair-Detroit River system (SCDRS), seasonal and annual flow variation is minimal. Increases in water temperature may trigger spawning, but in some systems such as the SCDRS, large latitudinal gradients in temperature are common as are differences in the timing of spawning and other life history events. We present data from the SCRDS where flow variation is minimal and latitudinal seasonal temperature variation occurs between the northern St. Clair and southern Detroit rivers. Spawning and larval emergence occurred earlier and larval densities were an order of magnitude higher in the Detroit River than the St. Clair River. Species examined in detail include lake sturgeon, suckers, walleye, and lake whitefish. Thermal influence of lakes Huron and St. Clair likely dictate spawning timing and possibly habitat availability in the rivers directly downstream for spring and fall spawning fishes using the SCRDS. These influences should be considered when developing habitat enhancement strategies and recruitment models for the early life history stages of fishes using the SCRDS. *Keywords: Recruitment, St. Clair River, Detroit River.*

DEINES, A.M.[1], BARNES, M.A.[1], BEE, C.A.[2], and LODGE, D.M.[1], [1]Department of Biological Sciences, University of Notre Dame, Notre Dame, IN, 46556; [2]Department of Economics, University of Notre Dame, Notre Dame, IN, 46556.. **A Bio-economic framework for harvesting invasive species.**

Harvesting, and sometimes eating, invasive species has garnered attention as a management option to reduce the impact of invasive species. We explore to what extent profit-driven harvests of invasive species could reduce the ecological and economic impact of invasive populations. Assessing these harvests requires understanding the interactions of a bio-economic system that links the market demand for invasive species products, the ecological impact of the species, and the rising costs of harvests as populations shrink due to harvesting. We combine well known bio-economic fisheries models with ecological models that relate the density of a harvested population to its ecological impact. In this way we develop a framework which can explore the ecological and economic outcomes of harvest. We explore predictions of this basic framework to evaluate scenarios of open-access harvesting, as well as harvests which are managed to maximize harvester profits or social benefits. We discuss the management implications of these different motivations for harvest- particularly in relationship to market incentives which may promote the intentional spread of target species. Using this framework, managers and researchers can design experiments and data collection to more completely evaluate the risks of harvesting invasive species. *Keywords: Economic evaluation, Biological invasions, Risk assessment.*

DELACH, D.L., CRIMMINS, B., and HOLSEN, T.M., Clarkson University, Potsdam, NY, 13699. **PFC concentrations in a Lake Superior Food Web.**

Perfloroalkyl compounds (PFCs) have a variety of properties that make them valuable components of commercial and consumer applications, as well as persistent environmental contaminants. Since their first reported presence in biota in 2001, PFCs have been identified as bioaccumulative and found worldwide in environmental media; fish have also been identified as a source of PFCs to humans. While their sources to the Great Lakes are still being characterized, these compounds have been detected in many components of the Lake Superior food web. Lake trout, cisco, and other fish of the food web were collected in 2011. Homogenates were extracted and analyzed for a suite of 23 perfluoronated compounds. PFCs were detected in all samples, with PFOS consistently measured at the highest concentration relative to other compounds. *Keywords: Environmental contaminants, PFOs, Lake Superior.*

DELEO, P.C., American Cleaning Institute, 1331 L Street, NW, Suite 650, Washington, DC, 20005. **Tools for Screening Environmental Risks of Consumer Product Chemicals in the Great Lakes Watershed.**

In the past decade, attention to chemical stressors in the Great Lakes has shifted from conventional and legacy pollutants such as those from industrial production or agricultural pesticides towards those in everyday household consumer products such as cosmetics, cleaning products and pharmaceuticals (sometimes referred to as Chemicals of Emerging Concern). The present talk will focus on tools to help characterize environmental risks of chemicals in consumer products. Participants will be introduced to exposure assessment tools to complement commonly available hazard screening tools for chemical risk screening. Emphasis will be placed on description of chemical inventories for major product categories like cosmetics, cleaning products and pharmaceuticals; and functional chemical classes like fragrances. The use of market volume information as a tool for understanding the extent of distribution of products and ingredients will be described. In addition, environmental exposure models such as iSTREEM® (http://www.aciscience.org/iSTREEM.aspx) which estimate chemical concentrations in wastewater-impacted receiving waters will be discussed. *Keywords: Consumer products, Risk assessment, Exposure, Assessments, Ecosystem modeling.*

DEMARCHI, C.[1], LOFGREN, B.M.[2], WANG, J.[2], BAI, X.[2], ABDEL-FATTAH, S.[3], and EWING, G.[4], [1]Department of Earth, Environmental, and Planetary Sciences, Case Western Reserve University, Cleveland, OH, 44106-7216; [2]National Oceanic and Atmospheric Administration, Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 48108-9719; [3]Department of Civil Engineering, McMaster University, Hamilton, ON, L8S 4L8; [4]Department of Civil and Environmental Engineering, University of Michigan, Ann Arbor, MI, 48104.
Comparing Coupled Hydrosphere-Atmosphere Research Model (CHARM) simulation of Great Lakes water temperature to the FVCOM model simulation and experimental data.

The Coupled Hydrosphere-Atmosphere Research Model (CHARM) is a Regional Climate Model developed at the NOAA Great Lakes Environmental Research Laboratory for hydro-climatological studies in the Great Lakes basin. CHARM features a 40-km spatial resolution and an explicit representation of the Great Lakes thermal structure with a modified Hostetler formulation. Although primarily used for understanding the possible impacts of Climate Change on lake water balance, recently CHARM projections of water temperature for future climate scenarios have been used to study the impact that climate change may have on Great Lakes fish population. In this study, we test CHARM capabilities of representing the Great Lakes water temperature when driven by reanalysis meteorological boundary conditions and boundary conditions generated by the Canadian General Circulation Model 3. Comparison is done for surface temperature and vertical profiles against temperature simulations by the 3-Dimensional FVCOM model and with observed data. *Keywords: Model testing, RCM, Climate change.*

DEPINTO, J.V., LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108. **Toward Operational Ecosystem Modeling to Support Adaptive Management in the Great Lakes.**

The Great Lakes community has long used mathematical models to support management and policy decision-making in the Great Lakes. The best example of successful use of models in the Great Lakes was the establishment of target phosphorus loads for the lakes to address eutrophication problems in the 1970s. However, once those models had supported the development of Annex 3 in the 1978 Great Lakes Water Quality Agreement Amendment, they were essentially "put on the shelf". If a process of operational modeling that allowed for routine evolution/updating and adaptive management through ongoing data collection and model application had been in place, the Great Lakes management community might have been in a position to avoid or at least anticipate the re-eutrophication of the Great Lakes that has been occurring over the past 15-20 years. This talk will present a plan for adaptive operational ecosystem modeling that recognizes the criteria for successful development of the process. An example of the process will be presented using the Saginaw Bay Ecosystem Model (SAGEM2) developed as part of the NOAA multi-stressor project. *Keywords: Mathematical models, Ecosystem modeling, Management.*

DEVANNA, K.M.[1], SMITH, R.E.H.[2], and LUDSIN, S.A.[1], [1]The Ohio State University, 1314 Kinnear Rd., Columbus, OH, 43212; [2]Univeristy of Waterloo, Waterloo, ON, N2L 3G1.
Understanding Fish Recruitment in Large Lakes: The Importance of Physical Processes.

Ability to understand and predict fish recruitment is a key goal of fishery management agencies in both freshwater and marine ecosystems. Toward this end, an increasing amount of recruitment-oriented research has focused on the effects of physical processes on early life stages (e.g., egg, larval, juvenile) growth and survival. The majority of this research, however, has been conducted in marine ecosystems and not their freshwater counterparts, despite both sets of ecosystems having similar physical processes and economically important fishes with life-history characteristics equally vulnerable to physical controls. Herein, we review the physical processes common to large lakes that may impact freshwater fish recruitment and compare and contrast the importance of these processes between lakes of differing size. In so doing, we present examples emphasizing the importance of physical forcing in regulating fish recruitment in the Laurentian Great Lakes. Given the similarities in physical and biological components between marine and freshwater ecosystems, we argue that understanding, predicting, and managing recruitment variation in the large freshwater lakes will require coupled physical-biological research and modeling approaches that are more typical of marine studies. *Keywords: Recruitment, Great Lakes basin, Water currents.*

DEWALT, R.E.[1], CAO, Y.[1], ROBINSON, J.L.[1], GRUBBS, S.A.[2], TWEDDALE, T.[1], and HINZ, L.[1], [1]Illinois Natural History Survey, 1816 S Oak, Champaign, IL, 61820; [2]Western Kentucky University, Dept. Biological Sciences, Bowling Green, KY, 42101. **Pre-European Settlement Range Predictions for Stoneflies (Plecoptera) of the Midwest.**

Animal distributions have changed dramatically within the Midwest during the 20th century. Stoneflies (Plecoptera) are sensitive to changes in water quality and habitat structure and the majority have lost range due to agriculture and urban development. Our approach to reconstructing their ranges uses 24,000 museum and new specimen records, ~100 environmental variables, and Maximum Entropy species distribution models to predict pre-European settlement range and species richness patterns across IL, IN, MI, OH, and WI. Applications include refinement of stream health measures based on expected richness, establishment of conservation status for species, prediction climate related range change, and assessment of the relative risk for

range loss for individual species. *Keywords: Midwest, Climate change, Plecoptera, Computer models, Aquatic Insects, Benthos.*

DIJKSTRA, M.L. and AUER, M.T., Great Lakes Research Center, Michigan Technological University, 1400 Townsend Drive, Houghton, MI, 49931. **An examination of interannual, seasonal and spatial dynamics in phytoplankton C:P stoichiometry in Lake Superior.**

Phytoplankton C:P ratios can provide information on nutrient status both in time and in space (both vertically and horizontally). Seasonal changes in phytoplankton C:P stoichiometry have been documented for the profundal waters of Lake Superior. Here, we compare C:P ratios in the nearshore shelf and slope waters of Lake Superior with those reported for profundal locations. Bi-weekly sampling was conducted at three stations (nearshore shelf, nearshore slope and offshore profundal) along a 26 km shore-perpendicular transect near Michigan's Keweenaw Peninsula for the April - October period of 2011 and 2012. A clear pattern in C:P dynamics is observed with lower C:P ratios in spring, increasing ratios in summer and lower ratios in fall. This pattern may be interpreted to indicate phosphorus sufficiency in spring and fall and an interval of striking phosphors depletion in summer. Patterns in C:P ratios are also compared for 2011, a year of average winter ice cover, and 2012, a year of little or no ice cover to examine the impact of differences in climate driven thermal regime on phytoplankton nutrient dynamics. *Keywords: Phytoplankton, C:P ratios, Lake Superior.*

DILA, D.K., NEWTON, R.J., and MCLELLAN, S.L., University of Wisconsin-Milwaukee, School of Freshwater Sciences, Milwaukee, WI, 53204. **Transient Signatures of Stormwater Runoff in Microbial Communities that Discharge to Nearshore Lake Michigan.**

Stormwater discharges are a major contributing factor to nutrient and pathogen input in the nearshore surface waters of the Great Lakes. As a major source of elevated levels of fecal indicators, traditionally enterococci and *Escherichia coli*, stormwater runoff is a leading cause of beach closings along Lake Michigan shoreline. Poor water quality puts both swimmers and local economies at risk, and any improvement in evaluating risk level will improve health and economic concerns. Runoff contains a diverse community of bacteria derived from animals and humans and these component parts can be characterized as unique signals. Separating human and non-human fecal community signatures facilitates a reduction in beach closings by targeting pathogen-associated runoff (the human signal). We sequenced the V6-V4 region of the 16S rRNA gene to characterize microbial communities from rivers, stormwater outfalls, the harbor estuary and nearshore Lake Michigan in Milwaukee, Wisconsin. By comparing microbial communities in wastewater treatment plant sewage before and after major storm events to communities in contributing and receiving surface waters, we found unique taxa in human and non-human sources. Microbial community signatures confirm that often nonpoint source runoff is the source of fecal pollution in nearshore waters. *Keywords: Coastal ecosystems, Microbiological studies, Water quality.*

DIMICK, S.E., Lake Superior State University School of Biological Sciences, 650 W. Easterday Avenue, Sault Ste. Marie, MI, 49783. **Variation in Round Goby Energy Density in the Great Lakes.**

Round goby, Neogbius mealanstomus, are an invasive species found in the Great Lakes since the 1990's. In recent years, round goby have become important prey for native predators such as lake trout, Salvelinus namaycush, double-crested cormorants, Phalacrocorax auritus, and Lake Erie water snakes, Nerodia sipedon. Because round goby are so important for the diets of other species, we tested whether round goby energy density varied seasonally and spatially in the Great Lakes. Seasonally, round goby energy density was highest in late summer and early fall (3,274 J/g) and lowest in spring (2,438 J/g). Across four sites in the Great Lakes, mean round goby energy density varied by less than 14%: from 3,649 J/g in northern Lake Michigan to 3,206 J/g in northern Lake Huron. However, differences were hard to separate statistically owing to the confounding factor of round goby length. The seasonal patterns in energy density were similar to previous findings in Muskegon Lake, Michigan, while the spatial differences in energy density suggests that round goby energy density varies by location. When combined with previous data, we can now better understand food-web linkages in the Great Lakes. *Keywords: Bioenergetics, Invasive species, Round goby.*

DOBIESZ, N.E. and HECKY, R.E., 2205 East 5th St, Room RLB 109, Duluth, MN, 55812.
The state of the Great Lakes fisheries - Why an integrated, lake-wide database system is critical but challenging.

Management of the Great Lakes is shared by Canada and the US, with many agencies providing monitoring and managerial support. This situation has given rise to several organizations that oversee and direct coordinated management. Agencies handling Great Lakes environmental monitoring have made considerable strides towards consolidating data and sharing it with researchers and the public through online tools. However, there has been much less success in consolidating lake-wide fisheries data and providing online access. Consolidating fisheries data is hampered by agency-specific long standing assessment procedures, and diverse data coding and formats that complicates data sharing and introduces problems of integrity, comparability, and quality assurance. But understanding the Great Lakes ecosystem through the inevitable system-wide changes it faces will require consolidated databases of all critical ecosystem data. We developed a prototype consolidated database and online visualization tools for Lake Superior. We describe the development and status of a common fisheries database and the value of integration of environmental and fisheries data. A brief demonstration of the globalgreatlakes.com web site will include currently available tools and proposed tools made possible only through a consolidated database. *Keywords: Fisheries, Data storage and retrieval, Fish management.*

DOLAN, D.M.[1] and RICHARDS, R.P.[2], [1]Natural and Applied Sciences, University of Wisconsin - Green Bay, Green Bay, WI, 54311; [2]National Center for Water Quality Research, Heidelberg University, Tiffin, OH, 44884-3352. **Daily Estimates of Phosphorus to Lake Erie for 2003-2011 with Enhanced Spatial Detail.**

As we grapple with the renewed eutrophication of Lake Erie, we are employing suites of models that are much more sophisticated than were available in the 1970s and 1980s, particularly in geographic and temporal detail. To fully utilize their capabilities, nutrient input data are required on a daily time step at nodes that represent the input locations of tributaries. A number of these are outside the main Lake Erie watershed, including inputs from Lake Huron and from small watersheds and numerous point sources along the Huron - Erie corridor that enter the Western Basin via the Detroit River. Included among these point sources is the Detroit sewage treatment plant, the largest point source of phosphorus to the entire Great Lakes. Over the last forty years, the magnitude of point source inputs has declined faster than that of non-point sources; non-point sources now dominate inputs to Lake Erie and to the Western Basin. All of this needs to be accounted for in assessing phosphorus impacts on Lake Erie. Since 2003, the total phosphorus loads to Lake Erie have been estimated on a daily basis at each of 26 spatial "nodes" located around the shore of lake. This paper will detail the methods and report the latest results for 2009-2011. *Keywords: Eutrophication, Lake Erie, Phosphorus.*

DOLL, J.C. and LAUER, T.E., Department of Biology, Ball State University, Muncie, IN, 47306. **Introduction to Bayesian Inference.**

Bayesian inference is becoming a popular method of statistical analysis in a variety of disciplines. In contrast to traditional methods (i.e., frequentist inference) Bayesian inference fundamentally differs in its definition of probability, how data are utilized, and how parameters are interpreted to make conclusions about a particular hypothesis. This presentation will discuss the major distinctions between Bayesian and frequentist inference including; how data and parameters are used, how the two methods evaluate hypotheses, and how the results differ. Further, the advantages and disadvantages of taking a Bayesian approach towards data analysis and how results of Bayesian inference are interpreted will be discussed. *Keywords: Computer models, Statistics, Model testing, Mathematical models.*

DOUCETTE, J.S.[1], MILLER, B.K.[2], and POLICINSKI, L.[3], [1]Department of Forestry and Natural Resources, Purdue University, 195 Marsteller St., West Lafayette, IN, 47907; [2]Illinois Indiana Sea Grant, 1101 W. Peabody Dr., Urbana, IL, 61801; [3]Envision Center for Data Perceptualization, Purdue University, 155 South Grant St, West Lafayette, IN, 47907. **Tipping Points and Indicators: Supporting Sustainable Communities in Great Lakes States.**

The way humans utilize the land has strong consequences for topics ranging from water quality to biodiversity. These impacts are pronounced in the Great Lakes states due to extensive agriculture and urban development. To protect the natural resources in this region, it is crucial to understand human-induced stress in the region, identify indicators of natural resource condition,

and determine the tipping points at which systems enter undesirable states.
The Tipping Points & Indicators website provides a Spatial Decision Support System that helps communities understand and plan for these issues. It is designed for use by outreach specialists to guide communities through the process of protecting their natural resource assets. In addition to educational content and tools there are wizards that guide the community through and overview of the community's land use and its effects on the community's natural resource assets followed by several action plan wizards for addressing specific natural resource concerns. Spatial analysis tools, dashboards, and what-if scenarios help the community explore their changing landscape.
Keywords: Decision making, Decision support systems, GIS, Planning.

DRISCOLL, Z.G. and BOOTSMA, H.A., 600 E. Greenfield Avenue, Milwaukee, WI, 53204.
Zooplankton Trophic Structure in Lake Michigan as Revealed by Stable Isotopes.

Soon after the offshore spread of *Dreissena rostriformis bugensis*, the total zooplankton biomass in Lake Michigan began to decline. *Daphnia mendotae* was one of the species most affected. In contrast, biomass of the large hypolimnetic copepod *Limnocalanus macrurus* has increased significantly, and the zooplankton community is now dominated by calanoid copepods. Little is understood about the mechanisms controlling these shifts, or their implications for food web structure and energy flow. To better understand the dynamics of this emerging zooplankton community, lower food web structure was examined by analyzing the isotopic composition of individual species, as well as three phytoplankton size classes. Nitrogen isotope analyses suggest that the phytoplankton and zooplankton community spans up to four trophic levels. *L. macrurus* consistently occupies the highest trophic level, while the invasive *Bythotrephes longimanus* occupies a level similar to that of other calanoids and cyclopoids. We discuss the implications of these findings in relation to energy flow and trophic efficiency within the Lake Michigan food web. *Keywords: Zooplankton, Lake Michigan, Stable isotopes, Food chains.*

DROTZ, M.K.[1], BERGGREN, M.[2], BRODIN, T.[3], WÄNGBERG, S.A.[5], and VON PROSCHWITZ, T.[4], [1]Lake Vänern Museum of Natural and Cultural History, Framnäsvägen 2, Lidköping, 53154, Sweden; [2]Dept. of Marine Ecology, Gothenburg University, Kristineberg 566, Fiskebäckskil, 450 34, Sweden; [3]Umeå University, Ecology and Environmental Sciences, Umeå, 901 87, Sweden; [4]Göteborg Natural History Museum, Slottsskogen, Box 7283, Gothenburg, 402 35, Sweden; [5]Gothenburg University, Department of Biological and Environmental Sciences, Gothenburg, 405 30, Sweden. **The Chinese Mitten Crab in Lake Vänern, Sweden.**

Single specimens of the Chinese mitten crab, Eriocheir sinensis H. Milne Edwards, 1853, have been regularly reported along the western and eastern coasts of Sweden since the 1930´s. Since 2001 a sharp increase in the occurrence has been noticed in Swedish inland waters, but the dispersal routes and distribution of the species into Sweden remain poorly known. Here we document the current and historical distribution of the crab in Sweden. A special focus is put on the occurrence of crabs in Lake Vänern and Lake Mälaren. In order to detect and monitor outbreaks of the mitten crab in Sweden, an internet based reporting system was created in 2007. The web-based reporting system was not advertised and the general public did not get paid for

reporting the information. Population densities of the crab occurred "in peaks" and unevenly over the last decade in both lakes, suggesting a pulse invasion instead of a constant supply by migration. Reports from the general public throughout Sweden coincide with the observations from local fishermen in Lake Mälaren and Lake Vänern. Data on occurrence and abundance are discussed in relation to a potential reproduction area on the western coast of Sweden. *Keywords: Invasive species, Lake Vänern, Management, Outreach.*

DUNCKER, J.J.[1], JACKSON, P.R.[1], JOHNSON, K.K.[1], and RENEAU, P.C.[2], [1]USGS-Illinois Water Science Center, 1201 W. University, Urbana, IL, 61801; [2]USGS-Wisconsin Water Science Center, 8505 Research Way, Middleton, WI, 53562. **Synoptic Survey of Near Shore Water Quality and Circulation in Lake Michigan Along the Chicago Lakefront.**

Researchers studying the fate and transport of bacteria in the near shore environment of southern Lake Michigan have focused efforts primarily on individual beaches susceptible to bacteria-related closings. On July 17-18, 2012 the U.S. Geological Survey, in cooperation with the Chicago Park District, completed a near shore survey of water quality and water circulation along a 20-mile reach of the Lake Michigan shoreline near Chicago, Illinois. The survey data was collected using an EcoMapper autonomous underwater vehicle (AUV). The AUV was programmed to swim a series of short transects (from offshore to onshore) while repeatedly undulating between the lake bed and the water surface and continuously logging it's position and water quality data from onboard sensors. The surveys started near Evanston, Illinois on July 17, 2012 and near the Illinois-Indiana state line on July 18, 2012 and both moved toward Chicago Harbor as the days progressed. A manned boat was used to launch and retrieve the AUV while also collecting acoustic Doppler current profiler (ADCP) data along each of the transect lines. Meteorological conditions such as wind speed and direction were recorded to document the relatively stable lake conditions during the 2-day survey. *Keywords: Lake Michigan, Nearshore, Hydrodynamics, Water quality.*

EDERER, S.L., Botany Department, University of Wisconsin-Madison, 430 Lincoln Dr., Madison, WI, 53715, **Plant-Microbial Associations and N Fixation: Sensitivity to Changing Moisture Levels in a Lake Michigan Beach-Ridge System.**

Extensive bryophyte groundcover in a beach-ridge ecosystem in Bailey's Harbor, Wisconsin was used to test the following hypotheses: (1) Bryophytes of wetland swales will harbor active N-fixing bacteria more often than bryophytes of adjacent dune ridges; and (2) Lack of water on short time scales (e.g., within a given day) limits the activities of N-fixing bacteria associated with bryophytes. These hypotheses were tested in paired upland/wetland ridge and swale sites at five areas. Nitrogen-fixing activity was measured in 300 bryophyte samples using the acetylene reduction assay (ARA) in the summer of 2011. Each sample was subjected to ambient moisture and to saturated conditions. A mixed-effects model was applied to the binomial ARA response data (0 = absence of N fixation, 1 = presence); predictors included two fixed-effects terms (wetland status and water treatment) and two random-effects terms (site nested within sampling date). Both wetland status and the water-addition treatment had significant positive effects on N fixation activity (p-values 2.83 x 10-5 and 0.0304). These results indicate that changes in water availability have the potential to change N cycling; as climate change modifies moisture availability in Great Lakes coastal wetlands, N fixation may change substantially. *Keywords: Coastal wetlands, Bryophyta, Biogeochemistry, Cyanophyta.*

EDSTROM, J.E. and SINHA, S.K., Environmental Consulting & Technology, Inc., 125 S. Wacker Dr, Suite 300, Chicago, IL, 60606. **Area of Concern Information Management and Tracking Systems.**

Environmental Consulting & Technology, Inc. (ECT) has developed two tools to track the status of BUIs and AOCs for USEPA-Great Lakes National Program Office (GLNPO). The first is the Environmental Restoration Information Management System (ERIMS) that assists individual AOCs in tracking BUI status and planning for their removal. ECT has worked with seven AOCs to develop ERIMS systems that allow environmental managers to bring together information that can be readily utilized in assessing environmental health, the status of local impairments, the need for specific projects or project types to address impairments, and monitoring needs. The ERIMS system allows the electronic tracking of impairments status, projects and potential projects that address the impairments, develops queries and creates maps. The second tool is an online AOC tracking system that integrates important documents and shows information on the status of all U.S. AOCs. The online tracking system is an internal tool for GLNPO and AOC managers to upload AOC delisting and BUI removal information and documents to provide an overview of status and allow for the easy exchange of information on BUI removals planning and execution. Both systems allow for better understanding of AOC planning and assist in developing pathways to delisting. *Keywords: Great Lakes basin, Areas of Concern, Environmental policy, Indicators.*

EGGLESTON, M.R., KOWALSKI, K.P., and BAUSTIAN, J.J., USGS Great Lakes Science Center, 1451 Green Rd, Ann Arbor, MI, 48105. **Northern pike (Esox lucius) access and recruitment in a hydrologically reconnected Lake Erie coastal wetland.**

Great Lakes coastal wetlands provide habitat for reproduction, refuge, and feeding by northern pike and many prey fish species. Unfortunately, the extent of and access to coastal wetlands diminished greatly since the late 1800s, especially in Lake Erie. Most remaining wetland areas have been isolated from Lake Erie by earthen levees, thus limiting access by common predator and prey fishes. In this study, northern pike populations were assessed in a 40 ha hydro-logically reconnected coastal wetland and its adjacent drowned river mouth estuary as part of a GLRI-funded habitat rehabilitation project. Fishes were sampled using fyke nets deployed both before and two consecutive years after reconnection. Abundance of Age-0 pike in the reconnected wetland increased significantly immediately after reconnection, and the overall abundance of northern pike (all ages) also increased significantly, even though pike population numbers in adjacent wetlands increased only slightly. These observations suggest northern pike are actively spawning and using the vegetated wetland as a nursery area. The rapid rate that northern pike started using the reconnected wetland and the significant increase in northern pike abundance are two of many positive responses to the management action and have implications for future rehabilitation efforts. *Keywords: Coastal wetlands, Restoration, Fish, Lake Erie.*

EISENHAUER, D.E., BARCLAY, P., BASTONI, C., HASSAN, M., LOPEZ, M., MEKIAS, L., RAMACHANDRAN, S., and STOCK, R., University of Michigan, 440 Church St, Ann Arbor, MI, 48109. **Using the Institutional Analysis and Development Framework to Understand Adaptive Capacity and Storm Water Management in the Face of Climate Change.**

Climate change is likely to significantly affect the Great Lakes region. Therefore, it is important to better understand how local communities and governments adapt and cope with these changes. We conducted sixty interviews with key governmental stakeholders to gather information regarding the adaptive capacity of four cities in Ohio: Toledo, Dayton, Elyria, and Avon Lake. To measure adaptive capacity, we describe capitals and capacities found to increase a system's ability to respond favorably to climate change. Using the Institutional Analysis and Development Framework, we investigate how each city manages its adaptive capacity to achieve adaptive outcomes. A key finding is each city is experiencing significant storm water impacts, such as erosion, combined-sewage overflows, and flooding. We find responses to these challenges varies between cities, though stakeholders in each are taking innovative approaches to better manage storm water. These approaches include broad stakeholder engagement, private-public partnerships, and forming regional networks. However, scarce resources, incomplete knowledge, and unclear vision constrain the potential of these initiatives to fully deal with projected impacts. We suggest strategies for improving stakeholder engagement to facilitate the emergence of adaptive storm water management. *Keywords: Climate change, Policy making, Planning.*

ELMER, H.L.[1], BRENNAN, A.H.[2], FERGUSON, O.[3], DORSEY, J.D.[4], HOHMAN, B.M.[5], and DYMOND, C.[5], [1]Old Woman Creek National Estuarine Research Reserve, 2514 Cleveland Road East, Huron, OH, 44839; [2]Chagrin River Watershed Partners, Inc., P.O. Box 229, Willoughby, OH, 44096-0229; [3]Consensus Building Institute, 238 Main Street, Suite 400, Cambridge, MA, 02142; [4]ODNR Division of Soil and Water Resources, 2045 Morse Road B-3, Columbus, OH, 43229; [5]Erie Soil & Water Conservation District, 2900 Columbus Avenue, Rm 131, Sandusky, OH, 44870. **Collaborative Learning to Implement Credits and Incentives for Innovative Stormwater Management.**

Urban runoff severely impacts Ohio's coastal communities and Lake Erie, and the traditional "end-of-pipe" ponds employed in most new developments do not adequately reduce or improve the quality of runoff. Low impact development (LID) attempts to address these problems by integrating natural landscape functions into site design and stormwater systems, but communities and engineers have asked for local performance research, design guidance, and training if they are to shift to using this new approach. In response, an interdisciplinary project team is using collaborative learning to engage professionals in research to generate credible and locally verified performance information about LID and other innovative stormwater systems. The project regularly convenes a group of engineers, utilities, developers, regulators, and watershed organizations for discussion on research priorities, criteria for monitoring site selection, and design of systems to be monitored though the project. This group of practitioners will help to shape design guidance and tools that managers can use to calculate the water quality treatment and flood control benefits of stormwater practices and provide input on development of credits and incentives for use of the most effective systems. *Keywords: Policy making, Stormwater, Management, Low impact development, Urban watersheds, Collaborative research.*

EMERY, S.M.[1] and RUDGERS, J.A.[2], [1]139 Life Sciences Building, Biology Dept., Univ. Louisville, Louisville, KY, 40292; [2]Dept. of Biology, 286 Castetter Hall, MSC03 2020, 1 University of New Mexico, Albuquerque, NM, 87131-0001. **Patterns of Fungal Symbiont Presence in Ammophila breviligulata Populations of Great Lakes Sand Dunes.**

Ammophila breviligulata is the dominant native grass of Great Lakes sand dunes. It stabilizes sand through prolific root production during the early stages of dune succession, and is considered a major ecosystem engineer. *Ammophila* is known to host a symbiotic fungal endophyte in its leaves, which may improve plant performance, alter root architecture, and enhance soil stability. *Ammophila* also forms facultative associations with mycorrhizal fungi in the soil, which can further enhance plant performance and dune stability. A geographic survey of endophyte frequency, mycorrhizal fungal abundance, and *Ammophila* traits at 37 sites, including three national parks, throughout the Great Lakes region showed that natural endophyte colonization was haphazard, and that endophytes had little effect on plant size. Mycorrhizal activity was negatively correlated with endophyte presence, positively correlated with plant diversity, and positively associated with latitude. A complementary field experiment showed that endophyte-inoculated plants had higher survival and growth, although plants without endophytes flowered more often. These studies indicate that endophyte presence could increase plant performance for *Ammophila*, while mycorrhizae might increase plant diversity along Great Lakes sand dunes. *Keywords: Vegetation, Coastal ecosystems, Populations.*

EPPING OVERHOLT, G., University of Wisconsin-Extension, 9501 W. Watertown Plank Road, Wauwatosa, WI, 53226. **The Evolution of an Engaged Citizen Stakeholder Citizen: A Model for Long-term Participation, Life-long Learning and Beneficial Use Impairment Removal.**

U.S. EPA policy requires Areas of Concern (AOC) to obtain citizen stakeholder approval when staff is ready to remove a Beneficial Use Impairment (BUI) or delist an AOC. Consequently, Milwaukee's agencies approach citizen engagement as an on-going process that strives to ensure such approval when needed. This case study uses place-based education and engagement, working with community partners that are proven leaders in community change with a presence in Milwaukee, even on the neighborhood scale. This case study will highlight how a Stakeholder Delegation was formed, how they have come together to gain a better understanding of the AOC Program, the process for delisting, the challenges of BUI removal and the commitment needed to bring cleaner waters back to Milwaukee. It stresses the importance of communicating a person's value to their community and the significance of local knowledge and history. The case study demonstrates the critical need to ensure citizen engagement is also about quality data and integrating policy and science, both ecological and social. This session concludes with the lessons learned from the pilot year of the Citizen Aesthetics Monitoring Program, and the elements that transform a bystander into an Engaged Stakeholder who collects valuable data. *Keywords: Monitoring, Stakeholders, Public participation, Milwaukee Estuary Area of Concern, Outreach, Aesthetics.*

ESSIG, R.R., TROY, C.D., CHAUBEY, I., CHERKAUER, K.A., and TAN, J., Purdue University School of Civil Engineering, 550 Stadium Mall Drive, West Lafayette, IN, 47907.
Nutrient Loading Spatial and Temporal Trends and Contribution Comparison of Lake Michigan Tributaries.

Many agencies have devoted resources towards identifying the factors affecting Great Lakes health and the success of restoration efforts. As part of this effort, the magnitudes and locations of tributary nutrient loading from base flows to Lake Michigan and other Great Lakes have been quantified using existing data. However, many of these estimations are driven by data that is temporally coarse, and studies of other systems have shown that storm events often deliver a high proportion of nutrients to receiving waters. This study attempts to quantify nutrient loading to Lake Michigan from eleven Lake Michigan tributaries using water quality and flow data with high temporal resolution. The data analyzed is from water grab samples and continuous water quality parameter time series collected by Purdue University and the United States Geological Survey (USGS). Discussed analysis focuses on creating water quality parameter relationships, and comparing temporal and spatial trends for nutrient loading with watershed land use maps and weather data. Results are compared with previous loading estimates for Lake Michigan. *Keywords: Nutrients, Tributaries, Spatial analysis.*

EVANS, M.A.[1], FAHNENSTIEL, G.L.[2], and SCAVIA, D.[3], [1]U S Geological Survey - Great Lakes Science Center, Ann Arbor, MI, 48105; [2]University of Michigan Water Center, Ann Arbor, MI, 48109; [3]Graham Environmental Sustainability Institute, University of Michigan, Ann Arbor, MI, 48109. **Inadvertent Oligotrophication of North American Great Lakes Part 2: Lakes Erie and Ontario.**

Seasonal phytoplankton productivity is the result of multiple ecosystem properties including nutrient availability, weather patterns, and the grazing environment. This productivity is, in turn, a bottom up control on food web dynamics and the provision of ecosystem goods and services. Thus, tracking and finding the causes of productivity trends for the North American Great Lakes through recent decades of intense ecological change is critical for managing ongoing and future changes. We show increases in spring silica concentration (an indicator of decreasing growth of the dominant diatoms) in both basins of Lake Ontario and the deep eastern basin of Lake Erie (USA, Canada) between 1990 and 2005, followed by stable production in Lake Ontario and slightly increasing production in Lake Erie. These changes indicate the lakes have undergone gradual oligotrophication coincident with the population expansion of invasive dreissenid mussels. The recent increasing production in Lake Erie's eastern basin follows increasing SRP loading to the western basin. This interactive effect of nutrient mitigation and

invasive species expansion demonstrates the challenges facing large-scale ecosystems and suggests the need for a new way to look at management regimes for large water bodies. *Keywords: Water quality, Zebra mussels, Phytoplankton.*

FAHNENSTIEL, G.L.[1], SAYERS, M.J.[1], SHUCHMAN, R.A.[1], and LESHKEVICH, G.[2], [1]Michigan Tech Research Institute, 3600 Green Ct., Ste. 100, Ann Arbor, MI, 48105; [2]NOAA-GLERL, 4840 S. State St, Ann Arbor, MI, 48108. **A Model for Determining Satellite-Derived Primary Productivity Estimates for Lake Michigan.**

A new MODIS-based satellite algorithm to estimate primary production (PP) has been generated and evaluated for Lake Michigan. The Great Lakes Primary Productivity Model (GLPPM) is based on the work of Fee (1973) and Lang and Fahnenstiel (1996) but utilizes remotely sensed observations as input for model variables. The Color Producing Agent Algorithm (CPA-A) developed by Pozdnyakov et al. (2005) and Shuchman et al. (2006, in press 2013) is utilized to generate robust chlorophyll values and the NASA KD2M approach is used to obtain the diffuse attenuation coefficient (Kd). Only incident PAR and carbon fixation rates are additionally needed to generate the PP estimate. Comparisons of the satellite-derived PP estimates from single monthly images to average monthly field measurements made by NOAA/GLERL found good agreement between estimates. Satellite derived PP estimates were used to calculate a preliminary Lake Michigan annual production of 8.5 Tg C/year. The GLPPM can be easily adapted to work on all the Great Lakes and therefore can be used to generate time series dating back to late 1997 (launch of SeaWiFS). These time series can contribute to improved assessment of Great Lakes primary productivity changes as a result of biological events, such as Dreissenid mussel invasions, climate change, and anthropogenic forcing. *Keywords: Remote sensing, Phytoplankton, Productivity.*

FEINER, Z.S.[1], CHONG, S.C.[2], FIELDER, D.G.[3], HOYLE, J.A.[4], KNIGHT, C.T.[5], LAUER, T.E.[6], PAOLI, T.J.[7], THOMAS, M.V.[8], TYSON, J.T.[9], and HÖÖK, T.O.[1], [1]Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN, 47907; [2]Upper Great Lakes Management Unit, Ontario Ministry of Natural Resources, Sault Ste. Marie, ON, P6A 2E5; [3]Alpena Fisheries Research Station, Michigan Department of Natural Resources, Alpena, MI, 49707; [4]Lake Ontario Management Unit, Ontario Ministry of Natural Resources, Picton, ON, K0K 2T0; [5]Fairport Fisheries Research Unit, Ohio Department of Natural Resources, Fairport, OH, 44077; [6]Department of Biology, Ball State University, Muncie, IN, 47306; [7]Peshtigo Service Center, Wisconsin Department of Natural Resources, Peshtigo, WI, 54157; [8]Lake St. Clair Fisheries Research Station, Michigan Department of Natural Resources, Harrison Township, MI, 48045; [9]Lake Erie Fisheries Research Unit, Ohio Department of Natural Resources, Sandusky, OH, 43440. **Evidence for plastic and adaptive variation in the maturation schedules of Great Lakes yellow perch across time and space.**

Variation in fish life history traits is driven by both plastic responses to current environmental conditions and adaptive responses to long term selection regimes. Disentangling plastic and adaptive variation in maturation is important because changes in the age or size at

which fish mature can impact stock recruitment, mortality, and resilience. In the Great Lakes, yellow perch (*Perca flavescens*) stocks constitute highly valuable fisheries and have experienced dramatic changes in harvest pressure and environmental conditions over time. These changing conditions may have altered their maturation schedules. Using Bayesian probabilistic maturation reaction norms, we quantified the maturation schedules of 14 populations of yellow perch, and evaluated plastic and adaptive differences both among stocks and temporally within stocks. Spatial variation in yellow perch maturation schedules appears to be largely driven by adaptive responses to their local environment. Temporal responses were more variable, but changes in fishing mortality (e.g., Lake Michigan) or growth environment (e.g., Saginaw Bay) have had strong effects on maturation schedules in some systems. This information could be used as an indicator of ecosystem change in these systems, in addition to informing management strategies for Great Lakes stocks. *Keywords: Life history studies, Yellow perch, Great Lakes basin.*

FENG, Q.Y.[1], CHAUBEY, I.[1], HER, Y.[1], WANG, X.Y.[2], and BOLE, C.[1], [1]Agricultural and Biological Engineering, Purdue University, 225 South University Street, West Lafayette, IN, 47907; [2]Texas A&M Agrilife Blackland Research and Extension Center, 720 East Blackland Road, Temple, TX, 76502. **Hydrological/Water quality impacts of perennial crop production on marginal land in the St Joseph River watershed.**

The Great Lakes basins areas are expected to play an important role in producing biomass for biofuel development. Production of biomass on marginal lands must be carefully evaluated to quantify unintended consequences of crop production on hydrology and water quality. In this study, the hydrologic/water quality impact of the projected cellulosic biomass production on marginal lands was evaluated using the Agricultural Policy/Environmental eXtender (APEX) model in the St. Joseph River watershed. Sixteen scenarios were developed to accommodate two cellulosic perennial grasses including switchgrass and Miscanthus and eight different types and sizes of marginal lands in the impact analysis. The watershed was divided into individual fields with unique soil and land cover combinations at different locations. Then, the model was setup and run for every field, and the field-scale modeling outputs were accumulated to quantify the hydrologic/water quality impact of the biomass production at the watershed scale. The simulation results demonstrated that the perennial crops production on marginal lands will likely reduce surface runoff volume, soil erosion rate, and nitrogen losses. We will discuss detailed scenario analysis results in this presentation. *Keywords: Watersheds, APEX, Computer models, Biofuel, Water quality, Land use change.*

FENG, Y.[1], ATKINSON, J.F.[1], BOYER, G.L.[2], and VERHAMME, E.M[3], [1]Department of Civil, Structural and Environmental Engineering, State University of New York at Buffalo, Buffalo, NY, 14260; [2]State University of New York, College of Environmental Science and Forestry, Syracuse, NY, 13210; [3]LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108. **Evaluation of Watershed Management Options to Reduce Phosphorus Loading in Sodus Bay Using a Coupled Ecosystem Model.**

An advanced aquatic ecosystem model, A2EM, coupled with an EFDC hydrodynamic model, is applied to investigate Microcystis outbreaks and possible management options to prevent such outbreaks in Sodus Bay, an embayment of Lake Ontario east of Rochester, NY. Initial model calibration has used on-site meteorological data, in-situ field water quality measurements, and algae sampling data from 2012 to determine parameter values that are not directly measurable or calculable, and additional confirmation and validation will be based on 2013 data. Phosphorus loading reductions as gradually being implemented throughout the watershed in the highly agricultural watershed are examined, so as mitigation of the phosphorus contribution from the bottom sediments during anoxic conditions, which was observed to be wide-spread in the summer of 2012. These results are reported back to the resource manager to make adjustments to the current monitoring and management plan. The ultimate goal of the model is to determine the relative importance of tributary and runoff phosphorus loading, bottom sediment mineralization, other sources, as well as hydro-meteorological conditions that may lead to the occurrence of algae blooms in the bay. *Keywords: Microcystis, Ecosystem modeling, Phosphorus.*

FERA, S.A.[1], MAYNARD, G.A.[2], and PAGNUCCO, K.S.[3], [1]Trent University, Peterborough, ON; [2]Lake Champlain Research Institute at SUNY Plattsburgh, Plattsburgh, NY; [3]McGill University, Montreal, QC. **Aquatic Invasive Species as a Driver of Change in the Great Lakes-St. Lawrence Basin.**

The Great Lakes-St. Lawrence River Basin contains uncommonly high concentrations and invasion rates of non-native species when compared to any other known freshwater system. The type of non-native species discovered in the Basin roughly corresponds to changes in the dominant vectors of invasion, including shipping and live trade. The impacts of established non-native species are intensified by the interactions of the invasives with other drivers of change in the Great Lakes-St. Lawrence River Basin. This paper discusses the important non-native species that have affected the Great Lakes-St. Lawrence River Basin over the last 50 years. Furthermore, changes in the dominant vectors of invasion the interactions between non-native species and other forces of change for the Basin and the regulations pertaining to invasions are examined. From this synthesis, we propose three alternate scenarios for invasive species in the Basin, 50 years into the future. By developing these three plausible future scenarios; a Utopian future, Status Quo, and a Dystopian future, we illustrate the importance of understanding and regulating invasive species to achieve a sustainable future for the Great Lakes-St. Lawrence River Basin.
Keywords: Environmental policy, Biological invasions, Ballast.

FERMANICH, K.J. and BAUMGART, P., University of Wisconsin Green Bay, 2420 Nicolet Drive, Green Bay, WI, 54311. **Landscape Sources of Phosphorus to Lower Green Bay: Concentrations, Loadings and Management Challenges.**

Non-point sources of phosphorus (P) dominate (75+%) the annual input to Green Bay. The vast majority (65 to 75%) of these runoff inputs originate in the Fox-Wolf River and Duck Creek basins. The Lower Fox River Basin (LFR) exports a disproportionate amount of landscape sources of P. Watershed management plans call for 40-70% reductions in landscape sources of P. Data collected during the last 10 years reveals that about half of all LFR tributary P is exported as dissolved P and that 80% of the annual P load typically occurs in <20 d. Median total P (TP) concentrations in tributaries exceed target concentrations (0.075 mg/L) by several times. More than half of all samples collected from agricultural source areas in the LFR Basin had TP concentrations >1 mg/L. However, field management tools show that farmers in these areas are meeting nutrient management guidelines. 2011 watershed-scale P loads exceed TMDL targets by up to a factor of 6. Meeting P loading targets for the bay of Green Bay and for associated tributaries requires management practices that significantly reduce landscape vulnerability to event driven P loss. In some areas reduced soil P levels are needed to decrease dissolved P export. In other areas perennial cropping, cover crops, etc. are needed to reduce TP losses.
Keywords: Phosphorus, Green Bay, Watersheds.

FETZER, W.W., JACKSON, J.R., and RUDSTAM, L.G., Cornell Biological Field Station, Cornell University, 900 Shackelton Point Road, Bridgeport, NY, 13030. **100 Years of Nearshore Fish Community Changes in Oneida Lake, NY.**

Understanding fish community responses to changing ecological conditions is a central challenge for fisheries management due partly to a general lack of available datasets that contain both the temporal and spatial resolution required to assess such changes. Oneida Lake, NY provides a unique opportunity because it is the site of a long-term monitoring program that samples both nearshore and offshore habitats. To date, only two studies have assessed the nearshore fish community (Adams and Hankinson 1928; Clady 1976). Here, we revisit these studies and incorporate additional data collected since the 1970s to assess for symmetrical species losses and recoveries following the loss of and subsequent reestablishment of littoral macrophytes. Preliminary results indicate a relatively stable fish community within nearshore habitats. Species declines/losses tend to be from historically rare species, while species increases are unlikely to be driven by the reestablishment of littoral macrophytes alone. Results highlight the importance of multiple factors in driving fish communities, including temperature, water clarity, and biotic interactions. *Keywords: Fish populations, Littoral zone, Habitats.*

FIELDER, D.G., Michigan Department of Natural Resources, Alpena Fisheries Research Station, Alpena, MI. **Saginaw Bay Walleye Recovery; Release from Environmental Stressors.**

Saginaw Bay, Lake Huron historically sustained the second largest walleye fishery in the Great Lakes but collapsed in the mid Twentieth Century due to a variety of environmental stressors including habitat degradation and effects of exotic species. Various initiatives over the years including the Clean Water Act slowly allowed for release from these stressors. A walleye fishery emerged in the 1980s but was dependent on stocking. The last release came in the form of the disappearance of the nonnative alewife from the bay and most of Lake Huron in 2004. Long believed to be an impediment to fry survival, in the absence of alewives, walleye reproductive success soared and today has reached recovery targets. Recent assessment performed on this stock is drawn upon to characterize the status of this important population and how its recovery has had implications for the rest of Lake Huron. This case study is a management success but also illustrates the recuperative powers of the Great Lakes ecosystems when relieved of stressors. *Keywords: Walleye, Ecosystem health, Exotic species.*

FILLINGHAM, J.H.[1], WANG, B.[2], BOOTSMA, H.A.[1], and LIAO, Q.[2], [1]School of Freshwater Sciences University of Wisconsin-Milwaukee, 600 E Greenfield Ave., Milwaukee, WI, 53204; [2]Department of Civil Engineering and Mechanics University of Wisconsin-Milwaukee, P.O. Box 784, Milwaukee, WI, 53201. **Towards a Parameterization for the CO2 Gas Transfer Velocity Useful for Biogeochemical Modeling of the Great Lakes.**

Previous studies have shown that the relationship between wind speed and the water-atmosphere transfer velocity of CO_2 (k) varies with water body size. We use these observed relationships as the foundation for a new parametrization of k for large lakes. CO_2 flux was measured under low to moderate wind conditions using the dynamic chamber method and an in-situ particle imaging velocimetry (PIV) system during several cases in the fall of 2012. The PIV system was used to measure the surface turbulent dissipation rate outside and under the chamber allowing for the correction of chamber induced turbulence. The empirically derived regression of k vs. wind speed for open water Lake Michigan, Milwaukee Harbor, and an embayment of the Kinnickinnic River in Milwaukee, WI is used to produce a broader scale relationship between k-wind speed slope and water body surface area. A wind-wave parameter is substituted for water body surface area, reflecting the intrinsic relationship between k and water body surface area, producing a parametrization useful for biogeochemical modeling on the Great Lakes. A comparison of modeled vs. measured CO_2 flux rates indicates the new wind-wave model is more accurate than traditionally implemented k parametrization. *Keywords: Atmosphere-lake interaction, Model studies, Carbon, Biogeochemistry, Waves.*

FISCHER, A.F. and PENNUTO, C.M., 1300 Elmwood Ave, Buffalo, NY, 14222. **The Round Goby (Neogobius melanostomus) Affects Microbial Community Composition and Leaf Litter Breakdown in a Lake Erie Tributary Stream.**

The round goby (Neogobius melanostomus) is a benthic, Ponto-Caspian fish introduced into the Great Lakes which has since secondarily invaded tributary streams and rivers. Various studies have shown they alter invertebrate communities, and these alterations have impacted organic matter decomposition. Stream studies suggest leaf litter decomposes less rapidly when gobies are present compared to locations where they are absent and we sought to determine whether the reduction in decomposition was a function of microbial community richness and diversity. Leaf litter packs were used as a substrate for microbial colonization and analyzed for leaf litter decomposition rates at sites with and without gobies present. Substrate consumption richness at the sample site without gobies was significantly less after 12-hours but significantly greater after 48-hours of incubation relative to the site with gobies. AWCD was greater at the site without gobies compared to the site with gobies. ACWD data at 48-hours and substrate consumption richness suggest that sites without gobies have greater community diversity compared to sites with gobies present. It could also suggest that the site without gobies favor faster growing microorganisms. Collectively these data suggest gobies may alter leaf litter decomposition by affecting microbial communities. *Keywords: Biological invasions, Round goby, Microbiological studies.*

FISK, A.T.[1], PETTITT-WADE, H.[1], TANNER, A.[1], KESSEL, S.[1], WEBBER, D.[2], STONE, T.[2], DOIRON, B.[2], KUEHNER, J.[2], and SMITH, F.[2], [1]Great Lakes Institute for Environmental Research, University of Windsor, 401 Sunset Avenue, Windsor, ON, N9B 3P4; [2]Amirix Systems Inc. / VEMCO, 20 Angus Morton Drive, Bedford, NS, B4B 0L9. **Fine scale movements of yellow perch and largemouth bass in semi-naturalized ponds using a High Residency acoustic telemetry positioning system.**

Study of fish movement rarely involves direct observation and there are limitations to the current understanding of fish behaviour. Acoustic telemetry can provide 2-D and 3-D positioning of fish. This is the first study to use a novel High Residency (HR) acoustic positioning system to track the movements of 10 yellow perch (*Perca flavescens*; two size classes ~50 and 250 g) and 4 largemouth bass (*Micropterus salmoides*) in semi-naturalized ponds. This HR system is an enhancement of the established Vemco Positing System(VPS) that allows more fine scale position data (every 1-3 seconds instead of 30-180 seconds) and more simultaneous tag use (reduced tag collisions). Data was compared to a VPS array in two other ponds. Movement of yellow perch was compared with and without the presence of the cruising predator largemouth bass. The HR-VPS system produced large amounts of data and fine scale resolution of movements and behavioural interaction. The majority of yellow perch inhabited pond edges, whereas a number of large yellow perch moved throughout the pond. Restrictions in movement were noticeable at night and in the presence of bass. This study highlights the caveats in current understanding of fish behaviour and the benefits of using HR acoustic positioning to study the fine scale movements of aquatic organisms. *Keywords: Largemouth bass, High residency, Yellow perch, Acoustic telemetry, Fish behavior.*

FITZPATRICK, F.A., WESTENBROEK, S., RENEAU, P.C., and BLOUNT, J., 8505 Research Way, Middleton, WI, 53562. **Baseline Geomorphic and Habitat Data for Great Lakes Rivermouth Habitat Improvement - Sheboygan River Area of Concern.**

Detailed data on the hydrologic, hydraulic, and geomorphic conditions of the lower 3 kilometers of the Sheboygan River were collected by the U.S. Geological Survey in 2011-12. These data were collected to assist WI Department of Natural Resources in the assessment and design of three large habitat improvement projects for the Sheboygan River Area of Concern. Data included georeferenced bathymetry, velocity, bank, and substrate measurements as well as continuous water level measurements. The water level measurements were referenced to river flows and lake levels. The geomorphic history and stability of an ecologically important island complex was studied to determine the age of the island complex and the effects of inundation of island surfaces on riparian vegetation. A 2-D channel hydraulics model is being developed for simulating the interplay of riverine flows with lake levels and sieche effects to determine the resiliency of hydraulic, geomorphic, and habitat conditions for both existing conditions and planned. In addition to assisting with restoration design, the modeling can be used as a tool to simulate future scenarios of climate change, including effects from record low levels of Lake Michigan to increased frequency and magnitude of sieche-driven water level changes related to storms and frontal systems. *Keywords: Hydrogeomorphology, Lake Michigan, Estuaries.*

FLANAGAN, D.C.[1], FRANKENBERGER, J.R.[1], WU, J.Q.[2], DUN, S.[2], and ELLIOT, W.J.[3], [1]USDA-ARS National Soil Erosion Research Laboratory, 275 S. Russell Street, West Lafayette, IN, 47907-2077; [2]Washington State University - Puyallup Res. & Ext. Center, 2606 West Pioneer, Puyallup, WA, 98371-4900; [3]USDA-Forest Service RMRS, 1221 South Main, Moscow, ID, 83843. **WEPP Modeling in the Great Lakes Basin.**

The USDA-ARS Water Erosion Prediction Project (WEPP) model is a state-of-the-art physical process-based computer simulation model for estimating runoff, soil erosion, and sediment losses from a range of land management systems, including cropland, rangeland, and forests. The National Soil Erosion Research Laboratory (NSERL) located at Purdue University supports and maintains WEPP, and works with cooperators around the country and world on model development and application projects. In the Great Lakes Basin, several efforts are currently underway. The NSERL is collaborating with the USDA-Forest Service and Washington State University on development of a web-based GIS tool for conducting WEPP model applications to forested watersheds around the Great Lakes, partially supported by a grant from the U.S. Army Corps of Engineers. In other work, WEPP is being applied to fields and watersheds in the Cedar Creek tributary of the St. Joseph River, under existing and projected future climate scenarios to evaluate the effectiveness of best management practices (BMPs) and how that effectiveness may change. This presentation will describe WEPP model and interface development efforts, as well as model applications currently underway and planned in the next few years. *Keywords: Sediment control, Erosion prediction, Assessments, WEPP, Watersheds.*

FLORENCE, C.V., MOORHEAD, D.L., and CRAIL, T.D., 2801 W. Bancroft St., Mailstop 604, Toledo, OH, 43606-3390. **Unionid abundance, diversity, size and dreissenid infection within and outside a thermal plume in Lake Erie.**

A community of unionids was discovered in the thermal plume of Bay Shore Power Plant in Oregon, Ohio. Previous analysis indicated this community was more diverse, had lower infection rates of dreissenids and exhibited higher recruitment than nearby unionid communities along the southwest shore of Lake Erie. In this study we made a more rigorous comparison between the Bay Shore community and an adjacent one at Cullen Park. Sampling transects were established at both locations and unionids were collected with basket rakes from 3, 1x1m plots at each sampling site (16 plots at Cullen and 18 plots at Bay Shore). Each unionid was identified to species, its length measured, the number of attached dreissenids counted, and immediately returned to the site. Seven species were found at both sites, six were shared. ANOVA revealed significant differences between the two communities in individual sizes, total density, diversity and evenness ($p \leq 0.05$). The community at Bay Shore had higher density, larger individuals, and lower infection by dreissenids, whereas the community at Cullen Park had higher evenness leading to higher diversity. Thus conditions at the power plant are not necessary to support a diverse unionid community despite the larger sizes, greater density and lower dreissenid infection at Bay Shore. *Keywords: Unionids, Biodiversity, Dreissena.*

FOBBE, D.J. and BERGES, J.A., Dept. Biological Sciences, U. Wisconsin-Milwaukee, 3209 N. Maryland Ave., Milwaukee, WI, 53211. **Epifluorescent Microscopic and Flow Cytometric Techniques for Bacterial and Viral Enumeration in Oligotrophic and Eutrophic Freshwater Systems.**

Bacteria and viruses are commonly counted using staining and epifluorescent microscopy, but such methods are imprecise and time consuming. Flow cytometric methods could improve the situation, but they have been used mostly in marine and only a few freshwater systems. We adapted protocols for freshwater samples ranging from oligotrophic Lake Michigan to a eutrophic urban pond. Essential steps included fixation and flash-freezing of samples within 2 h of collection and permeabilization with detergent and heat prior to staining of DNA (with SYBR green). With careful gating of samples on green fluorescence versus side scatter, bacterial and viral counts were achieved with an Accuri C6 flow cytometer that agreed well with epifluorescence counts and showed similar variability (cv about 20% among replicates). In addition to improved speed and precision, cytometry distinguished two viral populations that could not be separated using microscopy. Flow cytometry could be a routine and advantageous method of counting bacteria and viruses in freshwater systems. *Keywords: Flow cytometry, Viruses, Bacteria, Lake Michigan.*

FORSMAN, B.B. and MINOR, E.C., Large Lakes Observatory, University of MN-Duluth, 2205 East 5th St, Duluth, MN, 55812. **A flood case study. The bio-geochemical response of Western Lake Superior to the June 2012 Flood, a five-hundred-year storm event.**

In June 2012, between seven to ten inches of rain fell on the Duluth, Minnesota area in only twenty-four hours. Climate change models predict that while the region is likely to have less overall precipitation, large rain events will become more common. Therefore a study of the effects of this flood on Lake Superior may provide a glimpse of the future for scientists and managers. Lake Superior is the largest lake by area in the world and is normally oligotrophic with very clear water. The colored dissolved organic matter and suspended solids from the flood were visible across the western arm of the lake for weeks and could be seen clearly in satellite images. A coalition of local scientists measured the in-lake effects of this incredible input of sediment, nutrients, and organic matter over the summer and fall of 2012. Monitoring of carbon concentrations, total suspended solids, transmissometry, nutrient concentrations, and water color occurred at several near-shore and off-shore sites. Chlorophyll was expected to increase in response to the large input of phosphorus. However, preliminary results show that the algal bloom was suppressed by the increase in colored dissolved organic matter that reduced light penetration. *Keywords: Biogeochemistry, Climate Change, Lake Superior, Phosphorus, Dissolved organic matter, Monitoring.*

FORTIN, V.[1], YERUBANDI, R.[2], DUPONT, F.[1], SMITH, G.[1], ZHAO, J.[2], and PELLERIN, P.[1], [1]ASTD, Environment Canada, CMC, Montreal, QC; [2]WSTD, Environment Canada, Burlington, ON. **An Environmental Prediction System for the Great Lakes Based on Coupled Numerical Models.**

Environment Canada recently developed a coupled lake-atmosphere- hydrological modelling system for the Laurentian Great Lakes. This modelling system consists of the Canadian Regional Deterministic Prediction System (RDPS), which is based on the Global Environmental Multi Scale model (GEM), the MESH (Modélisation Environnementale Surface et Hydrologie) surface and river routing model, and a hydrodynamic model based on the three dimensional global ocean model Nucleus of European Model of the Ocean (NEMO). In this presentation, we will describe the performance of the NEMO model in the Great Lakes. The model was run in hindcast mode with atmospheric forcing from GEM and river forcing from MESH modeling system for the Great Lakes region and compared with available observations in selected lakes. The NEMO model is able to produce observed variations of lake levels, ice concentrations, lake surface temperatures, surface currents and vertical thermal structure reasonably well in most of the Great Lakes. Currently, the modelling system is further improved mainly in the resolution and coupling of atmosphere and lake models. *Keywords: Atmosphere-lake interaction, Hydrodynamic model, Ice.*

FRACZ, A., CARTWRIGHT, L., and CHOW-FRASER, P., 1280 Main Street West, Hamilton, ON, L8S 4K1. **Expansion of the URBAN - Urban-Rural Bio-monitoring and Assessment Network Program to train First Nations students.**

URBAN is a long-term citizen science program that started at McMaster University in January 2010 to track changes in biodiversity and the ecosystem. This program provides valuable ecological information on stream quality and wetland health for conservationists, city planners, resource managers, and researchers while at the same time educating citizens on the eco-services these natural resources provide. Our program monitors 7 streams and 22 marshes for amphibians, birds, plants, water quality and benthic invertebrates. While mainly focused within the Hamilton area, a new component of our program will be to conduct outreach to high school students of the Saugeen Ojibway Nation located near the Bruce Peninsula. Interactive seminars will be presented to students to teach them about careers in the environment and the influence of humans on the ecosystem. Students will be provided with hands-on activities to learn how to measure water chemistry in streams and to use benthic invertebrates as ecological indicators. Our goal is to create a long-term partnership with teachers in the Hamilton region and to continue growing and expanding our outreach and education program outside of Hamilton. *Keywords: Education, Outreach, Monitoring.*

FRAKER, M.E.[1], DEVANNA, K.M.[1], ANDERSON, E.J.[2], CHEN, K.Y.[1], DAVIS, J.J.[3], DUFOUR, M.R.[4], MARSCHALL, E.A.[1], MAY, C.J.[1], MAYER, C.M.[4], MINER, J.G.[3], PRITT, J.J.[4], ROSEMAN, E.F.[5], PANGLE, K.L.[6], TYSON, J.T.[7], ZHOU, Y.[8], and LUDSIN, S.A.[1], [1]Aquatic Ecology Lab, Ohio State University, Columbus, OH, 43212; [2]NOAA-GLERL, Ann Arbor; [3]Bowling Green State University, Bowling Green, OH; [4]University of Toledo, Toledo, OH; [5]Central Michigan University, Mt. Pleasant, MI; [6]USGS, Ann Arbor, MI; [7]Ohio DNR, DOW, Sandusky, OH; [8]Ontario MNR, Windsor, ON. **Coupled Physical-Biological Modeling as a Tool to Enhance our Understanding of the Recruitment Process in Mixed-Stock Fisheries: An Example with Lake Erie Walleye.**

Physical processes can generate spatiotemporal heterogeneity in habitat quality and can influence the dispersal of larval fish through hydrodynamic advection. The fact that individuals produced in different spawning locations or at different times experience dissimilar habitat conditions may underlie within- and among-stock variability in growth and survival. While such variation is likely to be important in driving intra- and inter-annual patterns in recruitment, the link between physical processes, larval dispersal, and larval growth and survival remains unstudied in most Great Lakes fishes. Herein, we used a hydrodynamic model coupled to a larval walleye (*Sander vitreus*) individual-based model to explore: 1) how the timing and location of larval emergence from several spawning sites in Lake Erie's west basin can influence dispersal pathways and mixing among these stocks; and 2) how spatiotemporal variation in habitat conditions can influence growth. In general, we found dispersal patterns and the degree of stock mixing to be variable. Consistent growth differences emerged among larvae from each site, attributable to spatiotemporal differences in temperature. Using these findings, we discuss the value of coupled biophysical modeling for understanding the recruitment process and addressing

fisheries management problem *Keywords: Hydrodynamic model, Dispersal, Walleye, Individual-based model, Bioenergetics.*

FRANCESCONI, W., SMITH, D.R., and HEATHMAN, G.C., 275 S. Russell St., West Lafayette, IN, 47906. **Using the APEX Model to Assess the Impact of Agricultural Conservation Practices in the Western Lake Erie Basin.**

Phosphorus losses from agriculture have been identified as a primary contributor to harmful algal blooms in Lake Erie. The objectives of this presentation will be to provide estimates of cropping systems management and other conservation practices that can be used to minimize P losses from this landscape. In the St. Joseph River watershed, a primary tributary to the Maumee River, USDA-ARS has been monitoring water quantity and quality from fields and agricultural drainage ditches. Cropping systems being tested at the field scale include corn/soybean rotation and alfalfa/corn/soybean/wheat/oats. These fields include long-term no-tillage (~20 yrs), rotational tillage (tillage only before corn), and conservation tillage (> 30% residue cover at planting). Conservation practices tested include grassed waterways, blind inlets, and conservation buffers. Additionally, the APEX model is being calibrated and validated to assess the potential impact of conservation practices on water quality in this landscape. This work will help guide future management decisions to minimize P loading to Lake Erie. *Keywords: Watersheds, Water quality, Management.*

FRANCOEUR, S.N.[1], PETERS-WINSLOW, K.A.[2], MILLER, D.R.[2], STOW, C.A.[3], CHA, Y.K.[3], PILLSBURY, R.W.[4], LOWE, R.L.[5], and PEACOR, S.D.[2], [1]Biology Department, Eastern Michigan University, Ypsilanti, MI, 48197; [2]Department of Fisheries and Wildlife, Michigan State University, East Lansing, MI, 48824; [3]NOAA / GLERL, Ann Arbor, MI, 48108; [4]Department of Biology and Microbiology, University of Wisconsin Oshkosh, Oshkosh, WI, 54901; [5]Department of Biological Sciences, Bowling Green State University, Bowling Green, OH, 43403. **Benthic Macroscopic Primary Producers in Saginaw Bay: Identity, Biomass, Distribution, Production, and Regulation.**

Benthic producers play important ecological roles in many lakes, but an overabundance of these organisms can lead to ecological and economic problems. Benthic primary producers often increase following invasion of Dreissenid mussels. We used surveys and experiments to examine the identity, biomass, distribution, production, and regulation of benthic macroscopic primary producers in Saginaw Bay from 2009 to 2012. Production and biomass in the inner bay were dominated by Charophtyes and macroscopic thalliod algae; vascular macrophytes were less abundant. Biomass maxima occurred between 2 and 3 m depth. Some inner bay filamentous algae were light-saturated, but light appeared to set the maximum depth of occurrence and may have limited growth in highly turbid areas. Inner bay filamentous algae were strongly P-stressed. An experiment at a typical inner bay site revealed strong nutrient limitation of filamentous algae and superior growth of filamentous algae on live Dreissenid mussels, likely in response to mussel nutrient excretion. A separate series of experiments confirmed that benthic algae in the outer bay remained strongly limited by P. This work extends our understanding of Great Lakes

benthic ecosystems, and provides insights for management of excess algae and beach fouling.
Keywords: Algae, Saginaw Bay, Littoral zone.

FRANCY, D.S. and MORRIS, J.R., U.S. Geological Survey, 6480 Doubletree Avenue, Columbus, OH, 43229. **Developing and Implementing the use of Predictive Models for Beach Advisories or Closings at 43 Great Lakes Beaches.**

Nowcasts that use predictive models to post advisories or closings are one means of providing rapid assessments of water quality at beaches. The U.S. Geological Survey worked with 22 local and state agencies to improve existing operational nowcast systems and expand the use of nowcasts throughout the Great Lakes. Models were developed for 43 beaches; the best model for each beach was based on a unique combination of explanatory variables including, most commonly, day of the year, wave height, turbidity, wind direction and speed, antecedent rainfall for various time periods, and change in lake level over 24 hours. Models were validated during 2012 and compared to the current method for assessing recreational water quality--using the previous day's E. coli concentration (persistence model). Twenty-four models provided overall correct responses that were at least 5 percent greater than the use of the persistence model. Preset model response goals were met more often by nowcast models than persistence models in terms of overall correct (80% goal--31 and 16%, respectively), specificity (85% goal--34 and 26%), and sensitivity (50% goal--19 and 4%). The USGS will continue to work with local agencies in 2013 and beyond on developing and improving models and implementing nowcasts.
Keywords: Human health, Beaches, Model testing, E. coli, Biomonitoring.

FREDETTE, T.J.[1], SUEDEL, B.[2], RUBY, R.[3], BIJHOUWER, P.[3], BANKS, C.[2], POLLOCK, C.[2], CLARKE, J.[2], and FRIONA, A.[3], [1]US Army Corps of Engineers, 696 Virginia Rd, Concord, MA, 01742; [2]3903 Halls Ferry Rd, US Army Corps of Engineers, Vicksburg, MS, 39180; [3]1776 Niagara St, US Army Corps of Engineers, Buffalo, NY, 14207. **Engineering With Nature: Increasing Habitat Value and Invertebrate Secondary Production on Great Lakes Coastal Structures.**

In April 2012 the US Army Corps of Engineers, with support provided by the Great Lakes Restoration Initiative, began a study to determine whether minor modifications to concrete blocks used to repair breakwater structures would result in increased habitat quality for invertebrate colonization. Normal repair procedures on Great Lakes breakwaters often involve the use of large precast concrete blocks. While breakwaters and similar structures are known to provide a variety of habitat opportunities, the block faces themselves offer little habitat value, yet these surfaces consist of the largest component of the structure. In an attempt to improve on this condition, the team hypothesized that increasing the surface texture (roughness) of the block surfaces would be beneficial for increasing colonization by algae, invertebrates, and potentially juvenile fish. The study involves three alternative modifications to the block surfaces, created by liners placed in the concrete block molds. Alternatives are a grooved block surface, a dimpled block surface, and the grooved texture combined with a shelf in the block profile. Unmodified control blocks were included as part of the study. Study site blocks were installed at the

Cleveland Harbor breakwater in April and May 2012 and the first monitoring occurred in October 2012. *Keywords: Breakwaters, Restoration, Coastal ecosystems, Rocky shore community, Macroinvertebrates, Habitat improvement.*

FREY, J.W.[1] and VAN METRE, P.C.[2], [1]5957 Lakeside Blvd, Indianapolis, IN, 46278; [2]1505 Ferguson Lane, Austin, TX, 78754. **The Midwest Stream Quality Assessment.**

In 2013, the U.S. Geological Survey (USGS) National Water-Quality Assessment Program (NAWQA) and USGS Columbia Environmental Research Center (CERC) will be collaborating with the U.S. Environmental Protection Agency (EPA) National Rivers and Streams Assessment (NRSA) to assess stream quality across the Midwestern United States. The sites selected for this study are a subset of the larger NRSA, implemented by the EPA, States and Tribes, to sample flowing waters across the United States. The goals are to characterize water-quality stressors--contaminants, nutrients, and sediment--and ecological conditions in streams throughout the Midwest and to determine the relative effects of these stressors on aquatic organisms in the streams. Findings will contribute useful information for communities and policymakers by identifying which human and environmental factors are the most critical in controlling stream quality. This collaborative study enhances information provided to the public and policymakers and minimizes costs by leveraging and sharing data gathered under existing programs. *Keywords: Monitoring, Water quality, Ecosystems.*

FRIEDMAN, K.B.[1], CREED, I.F.[2], KRANTZBERG, G.[3], LAURENT, K.L.[2], and SCAVIA, D.[4], [1]State University of New York at Buffalo, Buffalo, NY, 14260-1100; [2]Western University, Canada, London, ON, N6A 5B7; [3]McMaster University, Hamilton, ON, L8S 4L8; [4]University of Michigan, Ann Arbor, MI, 48104. **Scenarios for the Great Lakes-St. Lawrence River Basin: How "stories" of the future can inform present action and lead to a desired future for the Basin.**

The Great Lakes Futures Project is a multi-disciplinary, cross-sectoral initiative of 20 Canadian and US universities that aims to identify the major issues and uncertainties facing sustainability and thrivablity of the Great Lakes St. Lawrence River Basin using a process called scenario analysis. At a workshop held at the University of Michigan in January 2013, scholars, students, and policy leaders, agreed to pursue four scenarios based on the following two axes: (1) human capacity for change (x-axis) and (2) environmental-economic balance (y-axis). The intersection of these two axes provides four very different scenarios. This paper imagines a "future history" of each of the potential scenarios (- ++, +-, _+, --) for the Basin and summarizes the developments that have occurred in the Basin from 2000-2060. Based upon trends, quantitative analysis and expert input, the drivers of change within the Basin have different independent and interacting futures and are greatly impacted by their interaction with current policy thematic areas. By envisioning these very different scenarios, the Great Lakes Futures Project will bring to the surface hidden assumptions and risks, and indicate areas of potential policy reform and strategic research networks so that the desirable future is reached.
Keywords: Great Lakes basin, Scenario analysis, Future Scenarios.

FRY, L.M.[1], GRONEWOLD, A.D.[2], FORTIN, V.[3], BUAN, S.[4], CLITES, A.[2], LUUKKONEN, C.L.[5], HOLTSCHLAG, D.J.[5], DIAMOND, L.[4], HUNTER, T.[2], SEGLENIEKS, F.[6], DURNFORD, D.[3], KLYSZEJKO, E.[7], KEA, K.[8], and RESTREPO, P.[4], [1]Cooperative Institute for Limnology and Ecosystems Research, University of Michigan, Ann Arbor, MI; [2]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI; [3]Environmental and Numerical Prediction Research Section, Environment Canada, Dorval, QC; [4]NOAA National Weather Service, North Central River Forecast Center, Chanhassen, MN; [5]U.S. Geological Survey Michigan Water Science Center, Lansing, MI; [6]Boundary Water Issues, Environment Canada, Burlington, ON; [7]Water Survey of Canada, Environment Canada, Ottawa, ON; [8]Department of Civil and Environmental Engineering, Howard University, Washington, DC.
The Great Lakes Runoff Intercomparison Project Phase 1 (Lake Michigan): Summary of results and plans for Phase 2 (Lake Ontario).

Advances in regional hydrologic modeling since the development of the Large Basin Runoff Model (which remains a cornerstone in regional hydrologic modeling), have motivated the formation of the Great Lakes Runoff Intercomparison Project (GRIP), a binational collaboration to systematically assess models that are currently used, or could readily be adapted to simulate basin-scale runoff to the Great Lakes. In the first phase of GRIP, we applied 5 models to the Lake Michigan basin (GRIP-M), including the Area Ratio Method (ARM, from NOAA GLERL), Analysis of Flows in Networks of CHannels (AFINCH, from USGS), the Large Basin Runoff Model (LBRM, from GLERL), the Sacramento Soil Moisture Accounting Model encoded within the Community Hydrologic Prediction System (CHPS, from NOAA NWS), and Modélisation Environmentale Communautaire - Surface Hydrology (MESH, from Environment Canada). We found that, in general, the range of model skill and the variability between runoff estimates were less than expected, however, the analysis resulted in the identification of some avenues for improving the existing models for application to basin-wide flow simulation. This presentation will present findings from the GRIP-M analysis and describe how the team is moving forward with the next phase of analysis, in the Lake Ontario basin (GRIP-O). *Keywords: Hydrologic budget, Great Lakes basin.*

FUJISAKI, A.[1], WANG, J.[2], BAI, X.[1], LESHKEVICH, G.[2], and LOFGREN, B.M.[2], [1]University of Michigan, 4840 S State Rd, Ann Arbor, MI, 48108; [2]NOAA/GLERL, 4840 S State Rd, Ann Arbor, MI, 48108. **Model-simulated interannual variability of Lake Erie ice cover, circulation, and thermal structure in response to atmospheric forcing, 2003-2012.**

Interannual variability of ice cover, circulation, and thermal structure in Lake Erie for 2003-2012 was investigated using a three-dimensional hydrodynamic model coupled with ice processes. The model reproduced minima of ice extent in the winters of 2005-2006 and 2011-2012 (mild winters), as well as maxima in 2008-2009 and 2010-2011 (severe winters) in agreement with the observational analysis. The model results showed early onset of stratification after the almost ice-free winter of 2011-2012. In the mild winters, the coastal current speed was significantly higher than the 9-year mean, since the larger open water region allowed the more effective wind driven circulation. In the severe winters, the lake circulation was slowed because the packed ice reduced wind stress on the water surface. Seasonal means of coastal current speed

in the mild winters was almost double those in the severe winters, while the variation in the other seasons is much smaller. Decreasing ice cover could lead to a more energetic coastal circulation in winter. Finally, the interannual variation of ice cover is discussed in relation to teleconnection patterns. The ice minimum (maximum) in the winter of 2005-2006 (2008-2009) can be explained by the intermittent positive (negative) North Atlantic Oscillation event that occurred in January (December-January). *Keywords: Hydrodynamic model, Ice, Lake Erie.*

FULLARD, C.D.[1], CHIOTTI, J.[2], MURRY, B.A.[1], HAYES, D.B.[3], GALAROWICZ, T.L.[1], MADEL, G.M.[1], STOLLER, J.B.[3], and HAAS, M.D.[1], [1]Department of Biology, Central Michigan University, 200 Library Drive, Mount Pleasant, MI, 48859; [2]US Fish and Wildlife Service, Alpena Fish and Wildlife Conservation Office - Waterford Substation, 7806 Gale Road, Waterford, MI, 48381; [3]Department of Fisheries and Wildlife, Michigan State University, 480 Wilson Road, East Lansing, MI, 48824. **Characterizing changes in energy pathways leading to centrarchid top predators resulting from the secondary invasion of the round goby in Saginaw Bay tributaries.**

The secondary invasion of the round goby (Neogobius melanostomus) into Great Lakes tributaries may be causing changes to riverine food web dynamics. Previous studies have found elevated predation of round gobies by smallmouth bass (Micropterus dolomieu) in many areas of the Great Lakes where they co-occur, but this relationship is relatively unknown in lotic environments. Our stable isotope and stomach content analysis is nearly complete, which will help us understand the consequences of round goby to the energy pathways leading to two lotic predators, smallmouth bass and rock bass (Ambloplites rupestris) in three Saginaw Bay tributaries. We investigate whether predator trophic position and degree of round goby predation correlates with a gradient of round goby abundances. Round gobies are known to harbor elevated contaminant concentrations thus high use as prey by top predators has implications to human health and food web bioaccumulation. Using stable isotopes to detect such food web changes can be an important tool in the study of invasive species impacts to riverine food webs.
Keywords: Stable isotopes, Invasive species, Food chains.

FUSARO, A.J.[1], DAHLSTROM, A.A.[2], and KASHIAN, D.R.[2], [1]NOAA Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108; [2]Wayne State University, Department of Biological Sciences, 5047 Gullen Mall, Detroit, MI, 48202.
Mapping Cumulative Risk for Potential Great Lakes Invaders: Watchlist Species Assessments.

A thorough understanding of potential aquatic nonindigenous species (ANS) is necessary to provide a complete assessment of risks, which then facilitates successful active monitoring and prevention activities. Identification of and subsequent risk assessment for 'watchlist' species was initiated by the Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS). This project builds off those efforts and seeks to: 1) complete assessments for the 53 watchlist species identified by GLANSIS; 2) identify and complete assessments for additional potential invaders from vectors and geographic regions not encompassed by the GLANSIS list;

and 3) map the risk posed by these species, using Michigan as a pilot state. We present here a summary of the watchlist species and their potential for introduction, establishment, and impact in the Laurentian Great Lakes. A map incorporating these risks will be developed over the coming year to assist managers in prioritizing areas for active monitoring and area- or vector-specific prevention activities. This effort will help prevent primary introductions into the Great Lakes via ballast, biofouling, and live trade, as well as curb the spread of ANS beyond their current range via recreational activities, canals, and waterways. *Keywords: Invasive species, Risk assessment, Spatial analysis.*

GAIKOWSKI, M.P.[1], LUOMA, J.A.[1], WEBER, K.L.[1], ALOISI, D.B.[2], and MAYER, D.A.[3], [1]Upper Midwest Environmental Science Center, 2630 Fanta Reed Rd, LaCrosse, WI, 54603; [2]Genoa National Fish Hatchery, S5631 State Highway 35, Genoa, WI, 54632; [3]New York State Museum Field Research Laboratory, 51 Fish Hatchery Road, Cambridge, NY, 12816. **Efficacy and Non-Target Animal Safety of Formulated *Pseudomonas fluorescens* (*Pf*-CL145A) (ZEQUANOX®) used to Control Dreissenid Mussels in Limited, High-Value Open Waters.**

Controlling dreissenid mussels in fouled industrial water systems has historically required the use of expensive and hazardous oxidizing chemical control treatments. Efforts to identify a replacement for these chemical controls led to the discovery of *Pseudomonas fluorescens* (*Pf*-CL145A) by the New York State Museum's Field Research Laboratory. Cells of (*Pf*-CL145A) are toxic to zebra mussels following ingestion and the strain has subsequently been licensed, registered and commercially formulated (Zequanox®) as an industrial water treatment by Marrone Bio-Innovations (Davis, CA). We sought to evaluate formulated (*Pf*-CL145A) for use in limited, high-value open water locations for controlling dreissenid mussel infestations, particularly for native unionid mussel restoration efforts. Research included the evaluation of non-target effects in unionid mussels (7 species) and fishes (10 species). Controlled field research laboratory studies evaluated the efficacy of formulated (*Pf*-CL145A) for controlling dreissenid infestations. Field trials were conducted at two zebra mussel (*Dreissena polymorpha*) infested surface waters and compared different exposure doses and application methods. Safety (non-target mortality) and efficacy (zebra mussel mortality) in experimental trials will be discussed. *Keywords: Invasive species, Zebra mussels, Control systems.*

GANTZ, C.A.[1], KELLER, R.P.[2], LODGE, D.M.[1], GORDON, D.R.[4], JERDE, C.L.[1], and CHADDERTON, W.L.[3], [1]Department of Biological Sciences, University of Notre Dame, Notre Dame, IN, 46556; [2]Department of Environmental Science, Loyola University Chicago, Chicago, IL, 60660; [3]The Nature Conservancy, Great Lakes Project, South Bend, IN, 46617; [4]The Nature Conservancy, The University of Florida, Gainesville, FL, 32611. **Predicting invasive aquatic plant species in the Laurentian Great Lakes Basin using a questionnaire-style risk assessment.**

Risk assessment tools for invasive species can avert ecological and economic harm when they are coupled to management actions that reduce the introduction of high-risk species. One goal of our research is to reduce the number of invasions that occur from organisms in trade, one

of the largest sources of species introductions to the Great Lakes region. Our group has developed an aquatic weed risk assessment for use at both the U.S. and Great Lakes scales. This tool has high accuracy for identifying invasive and non-invasive species. It requires users to gather data to answer 38 questions about each species; these answers lead to a total score that is positively correlated with invasiveness. Score thresholds distinguishing invasive from non-invasive species are used to determine whether individual species pose an acceptable risk for inclusion in trade. If risk assessment approaches are adopted, it will be up to managers and other stakeholders to implement the assessment methods and decision-thresholds that are most appropriate for their region. Providing multiple thresholds from statistical analyses will optimize the decision-making process for all stakeholders. *Keywords: Exotic species, Risk assessment, Biological invasions.*

GARCIA-REYERO, N.[1], VILLENEUVE, D.L.[2], ESCALON, L.[3], HABIB, T.[4], EKMAN, D.R.[5], DURHAN, E.J.[2], KAHL, M.D.[2], JENSEN, K.M.[2], CAVALLIN, J.E.[2], BERNINGER, J.P.[2], COLLETTE, T.W.[5], ANKLEY, G.T[2], and PERKINS, E.J.[3], [1]Mississippi State University, Starkville, MS; [2]US EPA - MED, Duluth, MN; [3]US Army - ERDC, Vicksburg, MS; [4]BTS, Vicksburg, MS; [5]US EPA - ERD, Athens, GA. **Pathway-based Monitoring of Biological Effects at Great Lakes sites.**

The Great Lakes region suffers from degradation of water and environmental quality due to release of chemicals of emerging concern. Critical issues remain in delisting Areas of Concern (AOC) including determining sources of chemicals causing fish health impacts, relating health impacts to chemical exposure, and identifying causes of adverse health effects such as reproductive effects. Causal information would enable decision makers to identify more appropriate remedial actions thereby facilitating delisting of AOC. Fish placed in floating cages at different locations within AOC can be used to rapidly monitor the impacts of chemicals on fish health by analyzing chemicals in water, fish, and resulting impacts to fish health. Specific changes found in fish organs such as gonads and liver can be associated with specific effects. Here we show how a systems approach using transcriptomics, metabolomics, and other physiological endpoints has the potential to identify the health impacts caused by high-priority AOCs. We will also use changes at the molecular level to identify possible chemicals of concern based on associations with specific chemical exposures in the laboratory. We expect that this work will identify any potential health effects in fish leading to more accurate assessment of contaminant effects. *Keywords: Assessments, Omics, Fish.*

GAWDE, R.K.[1], VERHAMME, E.M.[2], AUER, M.T.[1], and DEPINTO, J.V.[2], [1]Great Lakes Research Center, Michigan Technological University, 1400 Townsend Drive, Houghton, MI, 49931; [2]LimnoTech Inc., 501 Avis Drive, Ann Arbor, MI, 48108. **The Thermal Regime of Lake Superior: Interannual Differences in Ice-Covered and Ice-Free Years.**

In large systems, like the Great Lakes and coastal oceans, physical processes have a significant influence on chemical and biological phenomena. Hydrodynamic modeling assists in characterizing these physical processes, specifically diffusive transport and circulation patterns

and their impact on heat content and thermal structure. In recent years, these models have been applied in the Great Lakes region to study the response of the lake ecosystem to long-term meteorological forcing conditions. Here, results from research utilizing the Environmental Fluids Dynamics Code (EFDC) model and focusing on differences in temporal and spatial trends in summer surface water temperatures, seasonal vertical stratification and development of the thermal bar in the western arm of Lake Superior for two consecutive summers (one preceded by average ice cover, 2011 and a second preceded by essentially no ice cover, 2012) are presented. *Keywords: Hydrodynamic model, Lake Superior, Ice.*

<u>GEBREMARIAM, S.Y.</u>[1], MARTIN, J.F.[1], DEMARCHI, C.[2], IRWIN, E.[3], ZHANG, W.[3], CHEN, N.[4], and LUDSIN, S.A.[5], [1]Food, Agricultural and Biological Engineering, The Ohio State University, Columbus, OH, 43210; [2]Department of Earth, Environmental, and Planetary Sciences, Case Western Reserve University, Cleveland, OH, 44106; [3]Department of Agricultural, Environmental and Development Economics, The Ohio State University, Columbus, OH, 43210; [4]Knowlton School of Architecture, The Ohio State University, Columbus, OH, 43210; [5]Department of Evolution, Ecology and Organismal Biology, The Ohio State University, Columbus, OH, 43210. **Impacts of Crop Management Practices in the Maumee Watershed on Dissolved Phosphorus Inputs to Lake Erie.**

During recent years, much evidence has been presented to indicate that Lake Erie is returning to a more eutrophic state. Interestingly, however, this re-eutrophication has been occurring at the time when (1) total phosphorus and sediment loads into Lake Erie have decreased, (2) application of best management practices reducing nutrient and sediment loss from watersheds has increased, and (3) point-source discharges have significantly decreased. Instead, an increase in dissolved reactive phosphorus (DRP) release associated with row crop agriculture in the Maumee Basin has been implicated, given that this watershed is the largest in the Great Lakes. The Maumee Basin is predominantly agricultural in nature and has increasingly experienced frequent and severe storms in recent years. Toward identifying best management practices that can minimize DRP release into Lake Erie, we used the Soil and Water Assessment Tool (SWAT) model to evaluate several row crop management practices, including filter strips, crop rotation and conservation tillage. Our model was calibrated for years 1995-2002 and verified with data from 2003-2011. In addition to presenting our results and offering recommendations on best row crop management practices, we identify critical information needed to improve our ability to model DRP load into Lake Erie. *Keywords: Eutrophication, Soil and Water Assessmenet Tool (SWAT), Model studies, Maumee Basin Landuse, Phosphorus, Dissolved phosphorus.*

GEREAUX, L.C., KENDALL, S.T., WEINKE, A.D., and BIDDANDA, B.A., Annis Water Resources Institute, 740 W. Shorline Dr., Muskegon, MI, 49441. **Observing Effects of Climate Anomalies and Episodic Weather Events on Muskegon Lake Phytoplankton Productivity Using Time-Series Data.**

Earth's climate is rapidly changing due to increasing greenhouse gas concentrations driven by anthropogenic activities. In addition to global warming, changes are expected in frequency, duration, and intensity of extreme weather events. Little is known about how ecosystems will respond to this rapid change. Ecological time-series observatories are useful tools to gauge ecosystem response to climate change. We used a lake based observatory with meteorological and water quality sensors to determine effects of recent climate anomalies and weather events on phytoplankton productivity in Muskegon Lake, Michigan. 2012 was the hottest year on record for the U.S. and also a year of severe drought for most of the country. Comparing 2012 with the previous year, it was determined that the timing of peak spring and summer algal blooms shifted earlier in the anomalous year. The peak values of chlorophyll a were similar between years, while the peak concentration of phycocyanin was reduced by approximately 50% from the previous year. This is counter to predictions that cyanobacteria blooms will increase with global warming. It is possible that decreased nutrient loading due to the drought, in addition to elevated summer wind speeds driving water column instability, contributed to conditions that were less favorable to cyanobacteria growth. *Keywords: Climate change, Observing systems, Phytoplankton.*

GLOEGE, L.J. and AUSTIN, J.A., Large Lakes Observatory, Duluth, MN, 55812. **Modeling the Distribution of Near-Inertial Energy in Lake Superior.**

Modeling results suggest that the distribution of bottom stress due to near-inertial oscillations in Lake Superior is spatially heterogeneous. Distributions of bottom stresses were studied under a variety of wind stress scenarios. The amplitude at the inertial frequency in the clockwise rotary spectrum of the data was used as a proxy for near-inertial energy and used to determine spatial distributions of near-inertial bottom stress . In general, high energy was observed in the open water and low energy closer to shore, though the distribution in the open waters was itself heterogeneous. Rotary wavelet analysis was used to determine the time evolution of the energy, including determining the amplitude and direction of propagation of near-inertial waves. These results may lead to a better understanding of bottom sediment distribution. *Keywords: Near-inertial, Modeling, Lake Superior.*

GOBIN, J.[1], LESTER, N.P.[2], COTTRILL, A.[3], FOX, M.G.[1], and DUNLOP, E.S.[2], [1]Trent University, 1600 West Bank Drive, Peterborough, ON, K9J 7B8; [2]Ontario Ministry of Natural Resources, 2140 East Bank Drive, Peterborough, ON, K9J 7B8; [3]Ontario Ministry of Natural Resources, 2045 20th Avenue East, Unit 12, Owen Sound, ON, N4K 5N3. **Changes in Maturation and Fishing Selectivity Through Time in Response to Declines in Growth of Lake Huron Lake Whitefish - What are the Implications for the Fishery?**

Growth and other life history traits affected by growth are key determinants of population dynamics. In several of the Great Lakes, lake whitefish have exhibited drastic declines in growth and condition as a result of changes in diet following the dreissenid invasion. Lake whitefish also support the largest commercial fishery in the Great Lakes and as such are subject to high fishing pressure, which can also influence life history traits and stock productivity. While these declines are expected to affect the productivity and sustainability of lake whitefish populations in the Great Lakes, little is currently known about the effects these changes have had, or are likely to have on the fishery in the future. Using data from the Ontario Ministry of Natural Resources Offshore Monitoring Program and the statistical catch-at-age stock assessment model for lake whitefish in the southern main basin of Lake Huron, we examined trends in growth, maturation, fishing, and the stock-recruitment relationship over the last 25 years. We found that not only has decreased growth resulted in delayed maturation, but it has also likely substantially increased the selectivity and fishing mortality of older mature individuals, that together could potentially have played a role in changes observed in the stock-recruitment relationship over time.
Keywords: Lake whitefish, Life history, Fisheries.

GOETTEL, R.G.[1], HALLESY, T.E.[1], MARTZ, M.A.[2], DOMSKE, H.M.[3], STEWART, S.R.[4], and HAGLEY, C.[5], [1]Illinois-Indiana Sea Grant, Univ. of Illinois, 390 NSRC, MC-635; 1101 W. Peabody Drive, Urbana, IL, 61801; [2]Pennsylvania Sea Grant, 301 Peninsula Drive, Suite 3, Erie, PA, 16505; [3]New York Sea Grant Institute, 229 Jarvis Hall, SUNY at Buffalo, Buffalo, NY, 14260-4400; [4]Michigan Sea Grant, 21885 Dunham Road, Suite 12, Clinton Township, MI, 48036; [5]Minnesota Sea Grant, 132 Chester Park, 31 W. College Street, Duluth, MN, 55812.
New Center for Great Lakes Literacy Creates Synergy among Educators, Scientists, and Citizen Scientists.

This session will offer a diverse array of activities from Sea Grant's Center for Great Lakes Literacy (CGLL). The Center works toward improving sustainability of Great Lakes watersheds by enhancing the stewardship ethic of those living in the basin. Through CGLL activities, we expect to develop a more Great Lakes-literate society prepared to make informed decisions and incorporate beneficial practices. Presenters will share methods used to build understanding about critical restoration issues/ concepts. In addition, we will highlight the 8 Great Lakes Literacy Principles integrated into CGLL's workshops and other educational practices. Activities will include the annual Great Lakes Shipboard Science workshop on the Lake Guardian, which connects scientists with educators; webinars and social media featuring pressing Great Lakes issues to foster teacher-scientist dialogue; land-based watershed workshops that facilitate strong community-school partnerships resulting in stewardship and restoration activities; and citizen science and other volunteer activities that create opportunities for adults to

become involved in watershed restoration. CGLL's strategy for creating a community of practice to build a vibrant network of Great Lakes educators, scientists, and stewardship organization professionals will also be discussed. *Keywords: Environmental education, Public participation, Great Lakes basin, Watersheds, Environmental health, GLRI.*

GOGINENI, P., JANUSKA, B., MINNIEFIELD, C., and SIMOLIUNAS, S., Detroit River Remedial Action Council, 665 West Warren Ave # 214, Detroit, MI, 48201. **The Unintended Cost of Clean Water Act.**

The unintended result of Clean Water Act was bumping up the costs to ratepayers by unneeded projects like building ineffective retention basins to control combined sewer overflows instead of separating rain pipes from sewer pipes and building ditches for rainwater capture. There should be federal standards not only for pollutants, but also for technology. The case in point is Rouge River Wet Weather Demonstration Project, which showed that retention basins do not work. However, Detroit Water and Sewerage Department subsequently built gigantic retention basins, which do not work, too. *Keywords: Cleanup, Economic evaluation, Legislation.*

GOODBERRY, F.N. and PEREZ FUENTETAJA, A., 9133 Hennepin Ave, Niagara Falls, NY, 14304. **The interacting effects of calcium decline and food level on Daphnia.**

Many physiological processes of Daphnia are negatively affected at low calcium concentrations. The concentration of calcium within lake water is determinant of how Daphnia populations will survive and reproduce in natural environments. Daphnia pulex-pulicaria were reared in FLAMES medium at three calcium concentrations (2.53mg/L, 1.0mg/L, 0.50mg/L) and high and low food levels (5.6 x 105 and 5.6 x 104) in a 2 x 3 factorial design. The experiment shows that at low calcium concentrations (< 1.0 mg/L) survival, individual reproduction, intrinsic rate of natural increase "r", time until first reproduction, molting and length of adult individuals and neonates were all negatively affected. Some of the physiological mechanisms exhibited interacting effects between calcium concentration and food level, in the case of lipid and ovary index food was more important than calcium concentration. This experiment offers insight into how daphniids in natural settings are responding to the multiple stressors that they are already facing in many freshwater lakes. *Keywords: Zooplankton.*

GORMAN, O.T., USGS, 2800 Lake Shore Drive East, Ashland, WI, 54806. **Restoration of the Native Fish Community in Lake Superior, Were We Successful or Just Plain Lucky?**

In the mid-1950's overfishing and sea lamprey depredation resulted in a collapse of Lake Superior's lake trout population and the fish community degraded rapidly afterwards. Exotic rainbow smelt increased rapidly and became the dominant prey fish and contributed to chronic recruitment failure in ciscoes and lake whitefish. Other native fishes also declined as a result of sea lamprey depredation, including large burbot, cisco, and lake whitefish. But populations of

some native species expanded in the absence of strong predation: sculpins, ninespine stickleback, trout-perch, round whitefish, and shiners. Massive stockings of hatchery lake trout eventually brought about a reduction in smelt populations and following successful treatments of lampricide in the early 1960s, remnant stocks of native lake trout began to reproduce. By the early 1980s, native lake trout populations expanded rapidly, smelt populations crashed, and native species rebounded. By the early 2000s the community was dominated by native lake trout, ciscoes, and whitefish. In retrospect, it is clear that some strategies for recovery may have worked better than others. Critical factors included persistence of remnant stocks of lake trout, successful lamprey control, closure and control of commercial fisheries, and suppression of exotic smelt populations.
Keywords: Lake Superior, Restoration, Ecosystem health, Fish communities, Fish management, Fish populations.

GRAYSON, T.S., 1200 Pennsylvania Ave, NW, Washington, DC, 20460. **The 2010 National Coastal Condition Assessment: Great Lakes Nearshore Survey Results.**

Since the 1990's, The US Environmental Protection Agency (USEPA) has conducted various research and monitoring programs to assess the condition of the nation's estuaries and coastal waters. Historically, the National Coastal Assessment (NCA) employed a probabilistic survey design and standardized indicators to determine the ecological condition of estuaries at national and regional scales. In 2010, the NCA became the National Coastal Condition Assessment (NCCA), a part of the Office of Water's National Aquatic Resource Surveys (NARS) program, implemented by USEPA and its state, tribal, federal agency and other entity partners. This is the first time that Great Lakes nearshore environments have been incorporated directly into the survey design, in order to determine a baseline of condition against which future assessments will be compared. Results of the 2010 Great Lakes nearshore assessment, as well as indicator and assessment thresholds development, and program enhancements will be presented.
Keywords: Assessments, Biomonitoring, Coastal ecosystems.

GREAVES, A.K.[1] and LETCHER, R.J.[2], [1]Department of Chemistry; Carleton University, Ottawa, ON; [2]National Wildlife Research Centre; Environment Canada, Ottawa, ON.
Organophosphate Flame Retardants are Maternally Transferred *In Ovo* in Herring Gulls (*Larus argentatus*).

Organophosphate flame retardants (OPFRs) have been detected in abiotic compartments although their levels are largely unknown in wildlife. In samples collected over the last 20 years we have shown that eggs of herring gulls (*Larus argentatus*) from across the Great Lakes contain at the highest frequency OPFRs tris(2-butoxyethyl) phosphate (TBEP), tris(2-chloroethyl) phosphate (TCEP) and tris(2-chloroisopropyl) phosphate (TCPP). The sum OPFR concentrations of these ranged from non-detect to as high as approx. 10 ng/g ww. Specifically, sum OPFR concentrations for pools of eggs from Chantry Island (Lake Huron) increased from about 0.5 to 3 ng/g ww between 1996 and 2010. In the present study, for gulls from Chantry Island (2010), we compared OPFRs in various tissues (liver, muscle, adipose, brain) and blood from maternal gulls (n=8) and their egg (yolk and albumen) clutches. Of the 12 OPFRs screened for, triphenyl phosphate (TPhP), tributyl phosphate (TBP) and TBEP (0.6-1.2 ng/g ww) were found in the yolk, whereas only TPhP was detected in the albumen. TCEP (1.6 ng/g ww) and TBEP (0.9 ng/g ww) were found in the liver of maternal birds, with TBEP being at comparable levels as in the yolk. This indicates that for OPFRs present in the liver of maternal gulls, there is in-ovo transfer and comparable levels of OPFRs in their eggs. *Keywords: Organophosphate Flame Retardants, Herring Gull, In Ovo Transfer.*

GREENE, A.K., BIXLER, S.M., MANZO, L.M., DIERKES, C., and HART, K.W., Ohio Sea Grant, 1314 Kinnear Rd., Columbus, OH, 43212. **Ohio State University's Stone Laboratory Climate Expedition: Engaging Learners with Local Implications of a Global Issue.**

Stone Laboratory, in Lake Erie's western basin, is the nation's oldest freshwater biological field station, and the center of Ohio Sea Grant's research, education, and outreach on Lake Erie. For over 35 years, Stone Lab has hosted students in grades 4-12 during spring and fall for a place-based field trip program. The *"Climate Expedition"* is a new activity with a focus on providing students with an introduction to the "Essential Principles of Climate Science". The *Climate Expedition* represents an effort to make climate change regionally relevant to those living in the Great Lakes basin. Our intention is to provide students with an understanding of Earth's climate, impacts of climate change, and approaches for adapting and mitigating change. The expedition features nine stations placed around Gibraltar Island, providing learners with information on climate science, and encouraging participants to analyze data, make predictions, and increase awareness of climate change in our local setting. Activities at three levels of difficulty address the needs of all learners as they explore each station. This presentation will provide an overview of: station topics, station alignment to Climate Literacy Principles, and questions from student lab sheets. Implementation results for the activity will be shared. *Keywords: Environmental education, Climate change, Education.*

GREY, E.K.[1], KRAUS, F.[2], BALDRIDGE, A.K.[1], KELLER, R.P.[3], and LODGE, D.M.[1], [1]University of Notre Dame, Department of Biology, South Bend, IN, 44617; [2]USDA National Wildlife Research Center, Fort Collins, CO, 80521; [3]Loyola University Chicago, Department of Environmental Science, Chicago, IL, 60660. **Herpetofauna Risk Assessment for the Great Lakes.**

Many exotic amphibian and reptile species are present in trade in the Great Lakes region. Despite the potential for economic and ecological impacts should these species become invasive, there are no quantitative herpetofauna risk assessments for the Great Lakes basin. In order to fill this gap, we are using an extensive database on successful and failed herpetofauna introductions to develop a predictive statistical model of establishment probability that considers invasion history, climate match and several biological and ecological species traits. We discuss the performance of this model and use it to quantify the risk of select species currently in trade in the Great Lakes basin now and under near-future climate scenarios. *Keywords: Exotic species, Amphibians, Risk assessment.*

GRIMM, A.G.[1], BROOKS, C.N.[1], SAYERS, M.J.[1], SHUCHMAN, R.A.[1], AUER, M.T.[2], MEADOWS, G.[2], and JESSEE, N.L.[1], [1]Michigan Tech Research Institute, 3600 Green Ct., Ste. 100, Ann Arbor, MI, 48105; [2]Michigan Technological University, 1400 Townsend Dr., Houghton, MI, 49931. **Mapping *Cladophora* and Other Submerged Aquatic Vegetation in the Great Lakes Using Satellite Imagery.**

The Michigan Tech team has developed and verified a remote sensing algorithm to map the extent of *Cladophora* and other submerged aquatic vegetation (SAV) in coastal waters using a depth-invariant bottom reflectance index. With this algorithm, maps of SAV were generated from recent Landsat satellite imagery for all optically visible areas of the lower four Great Lakes. The area mapped varies depending on water clarity, with maximum mapping depth ranging from >20 m in Lake Michigan to 7 m in Lake Erie. The maps show that 28%, 15%, 30%, and 40% of the visible bottom of Lakes Michigan, Huron, Erie and Ontario, respectively, are colonized by SAV. The total mapped area of SAV is estimated to represent between 130,000 and 260,000 metric tonnes dry weight based on published biomass density measurements. This new mapping approach was validated using field data for an overall map accuracy of 83%. The archive of Landsat imagery dating back to 1973 was also utilized to document historic changes in SAV extent and water clarity, showing increases in SAV extent in most areas following the introduction of invasive mussels. A seasonal analysis of SAV extent revealed intra-annual changes of ~5% or less. The time series analyses also captured the observed increases in water clarity in all four lakes. *Keywords: Benthic flora, Remote sensing, Submerged plants.*

GRIMM, E.F.[1], TROY, C.D.[1], STEIN, S.R[2], WILSON, A.E.[3], and HÖÖK, T.O.[2], [1]Purdue University - School of Civil Engineering, 550 Stadium Mall Drive, West Lafayette, IN, 47907; [2]Purdue University - Department of Natural Resources, 195 Marsteller Street, West Lafayette, IN, 47907; [3]Auburn University - Department of Fisheries and Allied Aquacultures, 321 Swingle Hall, Auburn, AL, 36849. **Characterization and mapping of river plumes in southern Lake Michigan.**

River plumes in the Laurentian Great Lakes are an important part of the coastal environment because they can bring sediment, nutrients, and pollution into the lake. River plumes in oceans have been studied extensively, but river plumes in large lakes, such as Lake Michigan, have received less attention. The dynamics of river plumes are especially important in light of restoration efforts because they determine the fate of materials delivered to the lake by riverine sources. A series of field surveys were carried out in southern Lake Michigan in order to characterize the fundamental properties of river plumes. Results from five river systems are presented, with the fundamental river plume properties and composition evaluated as a function of location/watershed and season. Water quality data of five different rivers will be presented to show how plume water can be identified in a river/lake situation based on basic measurements. Using these basic measures, maps are generated to determine the size and shape of the plume both in the horizontal and vertical direction. Additionally, dynamical predictors are presented, and these predictors allow for a quantitative evaluation of the relative importance of wind stress,

buoyancy, plume momentum, and other factors. *Keywords: Lake Michigan, River plume dynamics, Coastal processes, Hydrodynamics.*

GRONEWOLD, A.D., STOW, C.A., CAMPBELL, K., and HUNTER, T., NOAA, Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 48108. **Climate Change Impacts on the Water Budget and Water Level Dynamics of the Great Lakes Basin.**

Over the past several years, there have been unprecedented changes in the seasonal dynamics of the Great Lakes water budget. Record-setting precipitation and evaporation events, dramatic increases in lake surface water temperatures, and changes in ice area thickness and extent have collectively propagated into changes in the seasonal cycle of tributary inflows and water levels. From February 2011 through June 2011, for example, water levels on Lake Erie rose by over 0.8 meters (roughly 2.6 feet). Never before in recorded history had water levels on Lake Erie risen as much during a four-month period. Surprisingly, in the following year, water levels on Lake Erie dropped continuously for ten months (from December 2011 through October 2012). Until then, water levels on Lake Erie had always increased at some point during the traditional spring runoff period. These water level dynamics (along with water level dynamics on other lakes) reflect changes in winter snowpack, as well as the magnitude and timing of spring runoff, and underscore an important distinction between increasing variability, and persistent trends, in Great Lakes hydrological phenomena. *Keywords: Water level fluctuations, Climate change, Hydrologic cycle.*

GROULX, C.L., FRIEDMANN, K.E., and NINA, B., 115 Toronto Rd, Port Hope, ON, L1A 3S4. **The Port Hope Area Initiative Biophysical Environmental Assessment Follow-up Program for the Protection of Lake Ontario.**

The Port Hope Area Initiative (PHAI) involves the cleanup of historic low-level radioactive waste in various locations throughout the communities of Port Hope and Clarington, Ontario, Canada. It also includes the construction of two engineered aboveground mounds for safe long-term management of the low-level radioactive waste. Both the Port Hope Project and the Port Granby Project are located on the shores of Lake Ontario, including the Ganaraska River and small creeks. In 2006, a comprehensive Environmental Assessment (EA) was undertaken for each project resulting in the development and implementation of an Environmental Assessment Follow-up Program. The biophysical Follow-up Program includes environmental aspects related to the atmospheric environment, geology, groundwater, surface water, aquatic, and terrestrial life. This paper provides an overview of the Program development, and its implementation, focusing on project impacts to the Ganaraska River Watershed and the West Lake Ontario watershed. *Keywords: Lake Ontario, Watersheds, Environmental contaminants.*

GRUNDEL, R.[1], JEAN, R.P.[2], FROHNAPPLE, K.J.[1], GLOWACKI, G.A.[3], SCOTT, P.E.[4], and PAVLOVIC, N.B.[1], [1]U.S. Geological Survey, 1100 N. Mineral Springs Road, Porter, IN, 46304; [2]Dept. of Sciences and Mathematics, St. Mary-of-the-Woods College, St. Mary of the Woods, IN, 47876; [3]Lake County Forest Preserves, 32492 North Almond Road, Grayslake, IL, 60030; [4]Department of Ecology and Organismal Biology, Indiana State University, Terre Haute, IN, 47809. **Native Bee Ecology in Great Lakes National Parks.**

Concern over pollinator declines fuels the need to understand native bee ecology. We examined how plant diversity, nesting resources, woody vegetation density, patterns of human use of landscapes, and fire history relate to abundance of bees and composition of bee communities at Indiana Dunes National Lakeshore. Neither bee abundance nor richness or composition of bee communities within sites was significantly related to proximity of sites to each other. Species composition in less species rich sites was not merely a subset of species composition at richer sites. Lack of significant proximity or nestedness effects indicate bees' use of sites is shaped by factors at a small scale. Different sets of variables best predicted bee abundance, richness, and composition across the 25 sites surveyed. Bee abundance was significantly related to habitat structure and fire history, bee richness to floral richness, and bee community composition to floral richness and nesting resources. Human uses of the landscape did not significantly predict abundance or richness of bee assemblages. Results suggest that patterns of floral diversity, nesting resources, and habitat shading, present at the scale of a few hundred meters, are key determinants of bee community patterns in the mosaic grassland-savanna-forest landscape of the Indiana Dunes. *Keywords: National parks, Native bees, Pollinators.*

GRUNERT, B., LABUHN, S.L., and KLUMP, J.V., University of Wisconsin-Milwaukee School of Freshwater Sciences, 600 E. Greenfield Ave, Milwaukee, WI, 53204. **Comparative Effects of Climate on Green Bay Stratification.**

Green Bay is a dynamic system that experiences varying degrees of stratification throughout, with a shallow, unstable thermocline in the south and a deeper, more stable thermocline that can periodically break down and reform, depending on meteorological conditions and cold water incursions from Lake Michigan, in the north. As the regional climate continues to change, the time of formation, duration, and stability of the thermocline is expected to change as well. This study considered meteorological conditions and the thermal structure of the water column throughout Green Bay, south of Chambers Island. Using multiple data sets spanning four decades, trends in the onset and persistence of stratification with varying climatological conditions were observed. The impact of these findings on known biogeochemical cycles within the bay is considered. *Keywords: Climatic data, Green Bay, Comparison studies.*

GRUNERT, B.[1], KLUMP, J.V.[1], BRAVO, H.R.[2], and HAMIDI, S.A.[2], [1]600 E. Greenfield Ave., Milwaukee, WI, 53204; [2]P.O. Box 413, 2200 E. Kenwood Blvd., Milwaukee, WI, 53201. **Water Clarity and the Thermal Structure of Green Bay.**

Water color and clarity have been found to dictate the depth of formation and the stability of the thermocline in small lakes in various environments. The role of water color and clarity in large lake systems has been more contested, with speculation to the overall role in thermocline

formation and depth of the mixed layer. Previous studies in large lake environments have relied on relatively sparse data sets, both physically and temporally. This study considered the lower half of Green Bay, with moorings and short-term profiles throughout the bay characterizing the underwater light climate. These measurements, along with meteorological forcing data, were used to determine the effect of the water clarity on the overall thermal structure of the bay, including comparisons of observed data to data modeled using a 300m nested grid model based on the Princeton Ocean Model for the Great Lakes. Warming and cooling trends were observed, as well as degradation and reformation of the thermocline. A cross-correlation analysis on meteorological variables, water clarity, and temperature was run to determine which variables were most closely associated with these observations. *Keywords: Green Bay, Hydrodynamics, Princeton ocean model.*

GUNN, J.[1], CLARK, G.[2], DIANA, J.S.[1], HARRIS, V.[2], JENTES BANICKI, J.[3], LAPORTE, E.[1], ORLANDO, S.[3], PISTIS, C.[1], QUALLS, T.[2], and SAMPLES, A.[1], [1]Michigan Sea Grant, 520 E. Liberty St., Suite 310, Ann Arbor, MI, 48104; [2]Wisconsin Sea Grant, UW-Green Bay MAC 212, 2420 Nicolet Dr., Green Bay, WI, 54311; [3]Ohio Sea Grant, ODNR Office of Coastal Management, 105 West Shoreline Drive, Sandusky, OH, 44870. **The Green Marina Education Project: Using collaboration and technology to more effectively deliver training to marina operators.**

The Green Marina Education and Outreach Project supports existing and emerging Clean Marina programs by developing tools and incentives through a collaborative process designed to increase the adoption of best practices at marinas that prevent degradation to and/or improve the Great Lakes as a social, environmental, and economic resource. Project efforts are targeted at two key audiences: 1) marina operators, and 2) Clean Marina program staff (and/or state agency representatives where programs are still developing. The goal of the project is to facilitate a better understanding of Great Lakes sustainability, and have this understanding change the behaviors of marina operators as well as their patrons. As Great Lakes issues become more complex, costs to address these issues increase and public and private institutions are asked to do more with less. Collaborative efforts that seek to reduce costs through sharing resources are one way to ensure issues are addressed effectively. Through collaboration, the project leaders have created several learning tools that can be used in all Great Lakes States, while still addressing state and local differences. Publishing these tools online reduces printing costs, allows for faster updating of publications, and provides knowledge to a society where e-learning is becoming more common. *Keywords: Great Lakes Restoration Initiative (GLRI), Marinas, Education, Collaboration, Outreach.*

GUO, J.[1], LI, A.[1], CORCORAN, M.[2], ROCKNE, K.J.[3], GIESY, J.P.[4], and STURCHIO, N.C.[2], [1]2121 West Taylor Street School of Public Health West University of Illinois at Chicago, Chicago, IL, 60612; [2]Department of Earth and Environmental Sciences, University of Illinois at Chicago, Chicago, IL, 60607; [3]Department of Civil and Materials Engineering, University of Illinois at Chicago, Chicago, IL, 60607; [4]Toxicology Centre, University of Saskatchewan, Saskatoon, SK, S7N 5B3. **Spatial Distribution and Time Trend of Organic Pollutants in the Sediments of Lake Michigan.**

This work aims at revealing the spatial distribution and the temporal trend of selected legacy and emerging organic pollutants in the sediment of Lake Michigan. A total of 136 targeted organic pollutants in 29 surface sediment grab samples plus segments of a number of cores collected in 2010 and 2011 were analyzed using gas chromatography coupled with either electron impact ionization triple quadruple or electron capture chemical ionization single quadruple mass spectrometry. The targeted chemicals include polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs), polychlorinated biphenyls (PCBs), polychlorinated dipenyl ethers (PCDEs), polychlorinated naphthalenes (PCNs), organochlorine pesticides (OCPs), halogenated flame retardants (XFRs) and musk fragrances (MFs). Among XFRs, BDE-209 and 1,3,6,8-tetrabromocarbazole (TBC) were found to be the highest, followed by Dechlorane plus (DP) and 1,2-bis-(2,4,6-tribromophenoxy)ethane (BTBPE). In addition, a number of unknown brominated organics were found at relatively high concentrations. In surface grab samples, the concentrations of ΣPCDD/Fs, Σ_{38}PCBs, and Σ_3DDT had medians of about 0.3 ng/g dw, 7.4 ng/g, and 10.2 ng/g dw, respectively. Among MFs, AHTN and HHCB are the most detected.
Keywords: Organic compounds, Sediments, Spatial distribution.

GURHOLT, C.R. and UZARSKI, D.G., Central Michigan University, Brooks Hall 217, Mt. Pleasant, MI, 48859. **Seed Bank Purgatory: What Drives Compositional Change of Great Lakes Coastal Wetlands.**

Variations in water levels due to climate change could have severe consequences on Great Lakes coastal wetlands. Seed banks address future potential for wetland vegetation. Seven coastal wetlands were sampled in 2012. A transect was established perpendicular to the tree line at each site and four quadrats were set equidistant from one another along each transect. Five core samples were collected in each quadrat and seed specimens from each transect location were grown in individual planters. Non-metric multidimensional scaling (NMDS) of species data at each site showed a stratification by ecoregion. Lacustrine sites were similar, whereas drowned river mouth sites were much more variable, though the two ecosystem types were still significantly different (MRPP p-value=0.002). Principal components analysis (PCA) of the abiotic data showed differences between site types: the drivers were redox potential, alkalinity, dissolved solids, and dissolved oxygen. A Pearson correlation ($r = 0.498$) showed a significant relationship between NMDS axis 2 and PC 2. Inter-annual water level changes directly influence wetland plant species diversity. Therefore, our study addressing the composition of seed bank species related to abiotic variables may be useful in predicting responses of wetland vegetation elicited by climate change. *Keywords: Vegetation, Climate change, Wetlands.*

HAHN, C.M.[1], IWANOWICZ, L.R.[2], BLAZER, V.S.[2], and MAZIK, P.M.[3], [1]West Virginia University, 322 Percival Hall, Morgantown, WV, 26505; [2]Leetown Science Center - Fish Health Branch, 11649 Leetown Road, Kearneysville, WV, 25430; [3]3USGS - WV Coop Research Unit, 322 Percival Hall, Morgantown, WV, 26505. **Biological Effects of Environmental Contaminants on Gene Expression Endpoints in Fishes of the Great Lakes.**

A recent shift in environmental monitoring of the Great Lakes watershed includes the evaluation of a new group of compounds collectively referred to as contaminants of emerging concern (CECs). Perhaps one of the best studied classes of CECs is that of the endocrine disrupting compounds (EDCs). A multiagency project is in progress to evaluate the significance of such chemicals on aquatic biota inhabiting the Great Lakes basin. A component of this project involves the evaluation of biological perturbations in resident pelagic smallmouth bass and largemouth bass, and the benthic brown bullhead and white sucker throughout the Great Lakes Basin, but primarily in locations proximate to Great Lakes Areas of Concern (AOCs). Using next generation sequencing technologies biomarker genes were identified in these non-model species and gene expression analyses were conducted via qPCR or nCounter analysis. Gene expression analysis was designed to complement the histopathological, plasma and other observations on the same individuals. It will also be compared to similar data available from caged fathead minnow studies performed by the Environmental Protection Agency. In addition, genomic DNA has be collected for microsatellite analysis and population assignment. The results and significance of these analyses will be discussed. *Keywords: Environmental contaminants, Endocrine disruption, Genetics.*

HAJIBABAEI, M.[1], BAIRD, D.J.[2], GIBSON, J.[1], KING, I.[1], MONK, W.[2], and SHOKRALLA, S.[1], [1]Biodiversity Institute of Ontario, Department of Integrative Biology, University of Guelph, Guelph, ON, N1G 2W1; [2]Environment Canada @ Canadian Rivers Institute, Department of Biology, University of New Brunswick, Fredericton, NB. **Ecosystem biomonitoring through DNA metasystematics.**

Next-generation sequencing (NGS) technologies have enabled direct sequencing of bulk environmental samples containing assemblages of species from various taxonomic groups to provide monitoring capacity at community and whole ecosystem levels. A DNA metasystematics approach provides the ability to characterize shallow and deep phylogenetic levels in all domains of life by analyzing a selected suite of biodiversity genomic marker genes such as species-specific DNA barcodes. Efficient execution of DNA metasystematics approach necessitated development and optimization of workflows at various steps from sampling regime to genomics data gathering through NGS to bioinformatics and data analysis. We have tested the utility of this approach in ecosystem biomonitoring in various settings including tropical rainforests, a major North American urbanization gradient and sites adjacent to large-scale industrial activities. Here we provide an overview of the DNA metasystematics approach, giving specific examples of current workflow, and illustrate its application in ecosystem assessment.
Keywords: Biomonitoring, Genomics, Genetics, Phylogenetics, Biodiversity, Ecosystem.

HALLESY, T.E.[1], GOETTEL, R.G.[1], KAMMIN, L.K.[1], MCCARTNEY, A.B.[2], MARTZ, M.A.[2], KELCH, D.O.[3], and DOMSKE, H.M.[4], [1]1101 W. Peabody Dr., Urbana, IL, 61801; [2]301 Peninsula Dr., Suite 3, Erie, PA, 16505; [3]42110 Russia Road, Elyria, OH, 44035; [4]229 Jarvis Hall, Buffalo, NY, 14260. **Undo the Great Lakes Chemical Brew: Changing How People Use and Dispose of Their Pharmaceuticals and Personal Care Products.**

In 2010, Sea Grant programs in Pennsylvania, New York, Ohio, and Illinois-Indiana joined forces to start the highly successful *Undo the Great Lakes Chemical Brew* project, funded by the Great Lakes Restoration Initiative. Together, the *Undo the Chemical Brew* team has collected 2.7 million pills for proper disposal and informed over 1 million anglers, educators, students, 4-H youth, medical professionals, legislators, and community members in the Great Lakes basin about how they can take action to improve water quality in the Great Lakes. The team will share successful outreach and educational approaches to providing science-based information that helps people understand how their use and disposal of pharmaceuticals and personal care products impacts the environment. *The Medicine Chest* curriculum, *Sensible Disposal of Unwanted Medicine 4-H Guide*, and informational newspaper inserts provide teachers and students with engaging stewardship activities so that they can take what they have learned and share it with others in their community. The team will highlight examples of successful stewardship projects. *Keywords: Outreach, Great Lakes Restoration Initiative (GLRI), Pharmaceuticals and personal care products, Environmental education, Ecosystem health, Environmental contaminants.*

HAND, B.K.[1] and BOLEN, B.[2], [1]Tetra Tech, Inc., 1 South Wacker Drive, Suite 3700, Chicago, IL, 60606; [2]U.S. EPA Great Lakes National Program Office, 77 W. Jackson Blvd. G-17J, Chicago, IL, 60604. **Protecting the Integrity of the Great Lakes through Increased Preparedness, Monitoring, and Response Capabilities for Asian Carp and Other Aquatic Invasive Species.**

Early detection combined with effective rapid response is critical to preventing the establishment of aquatic invasive species (AIS) into new waterways and thus minimizing the potential ecological and economic impacts. An operational rapid response plan using traditional emergency response doctrine brought together multiple agencies to respond to the potential presence of Asian carp in the Chicago Area Waterway System and prevent their movement into the Great Lakes. Management guides, operational plans, training modules, and exercise opportunities have since been used as tools against AIS to ensure agency officials and involved stakeholders are prepared for and committed to implementing rapid response operations following AIS introductions. These tools have been designed to account for the affected jurisdictions, expansive geographical area, and complexity of the Great Lakes Basin. The goal of these efforts is to develop a standardized approach to response, advancement of mutual-aid agreements, and response management training. Implementation of the developed tools and plans will increase the overall regional response capabilities through early and sustained stakeholder involvement in preparedness and response activities. This presentation demonstrates the tools available and their applicability to Great Lakes stakeholders. *Keywords: Invasive species, Rapid response, Planning, Asian carp.*

HAPPEL, A.H.[1], RINCHARD, J.[2], CREQUE, S.[1], HÖÖK, T.O.[3], BOOTSMA, H.A.[4], JANSSEN, J.[4], and CZESNY, S.J.[1], [1]Lake Michigan Biological Station, University of Illinois-Urbana Champaign, Zion, IL; [2]Dept. Of Environmental Science and Biology, The College at Brockport- SUNY, Brockport, NY; [3]Dept. of Forestry and Natural Resources, Purdue University, West Lafayette, IN; [4]Great Lakes Water Institute, University of Wisconsin-Milwaukee, Milwaukee, WI. **Depicting Spatial Heterogeneity through Concomitant Dietary Analyses.**

Accurately describing and quantifying species' diets is a pervasive challenge for ecologists. In contemporary analyses, fatty acid signatures and stable isotope ratios have been paired with stomach content data to provide dietary assessments of aquatic species. Within freshwater systems, few studies have employed multiple dietary indicators concomitantly to investigate current predator-prey interactions. Recent alterations to Great Lakes fish communities (i.e. invasive species) drastically alter energy pathways through food webs. How species interactions have responded to these perturbations across spatial gradients has yet to be determined. We utilized spatial heterogeneity within Lake Michigan's coastal system to compare and contrast three dietary techniques. As an opportunistic forager, yellow perch were chosen as a model species to elucidate spatial dietary trends through multiple dietary analyses. Technique specific time frames allowed for differing depictions of diet trends. Our results indicate that pairing fatty acid data with stomach content data provides depictions of both instantaneous and time integrated dietary trends. Conversely, stable isotopes' extended turnover rates do not provide expedient information on migrating juvenile fish's diets. *Keywords: Yellow perch, Fatty Acid Signatures, Stable isotopes, Lake Michigan.*

HASHSAHM, S.A., Department of Civil and Environmental Engineering and Center for Microbial Ecology, Michigan State University, East Lansing, MI, 48824. **Merging Genomics and Microfluidics to Develop Low Cost Genetic Analysis Systems and Approaches for Environment and Health.**

Over the past decade, tremendous progress has been made in genomics, microfluidics, and miniaturization of analytical systems. Combined with consumer electronics, this progress can now be translated to develop rapid, rugged, and powerful devices capable of carrying out high end diagnostics in a cost-effective manner without sophisticated lab and trained personnel. We have developed two extremely low-cost devices along with the associated microfluidic chips and validated them for a number of applications in the area of health, food and agriculture, and environmental monitoring. One of these device, named Gene-Z, is an iPod driven genetic analysis system with the following specifications: i) microfluidic DNA biochips containing up to 64 reactions, ii) application specific biochips (clinical, antibiotics, water), iii) isothermal or temperature cycling based amplification, iv) quantitative results similar to real time PCR, v) sample volume: less than 40 μl, vi) limit of detection: 10-100 copies per reaction well, vii) Assay time: 5-30 minutes, and viii) lowest cost equipment weighing less than one pound. It uses light emitting diodes for excitation and photodiode as a detector. Because of the use of simpler components the cost of these devices and assays are significantly lower. *Keywords: Analysis, Microfluidics, Genomics.*

HAUNERT, N.W. and LAUER, T.E., Cooper Life Science Building, CL 121, Muncie, IN, 47306. **Seasonal Variations in GSI for Yellow Perch in Southern Lake Michigan.**

Yellow perch (Perca flavescens) were collected from 2009 to 2012 using gill nets set at four sites in the Indiana waters of southern Lake Michigan to determine how gonadal somatic index (GSI) varied before, during and after spawning. The largest GSI was found during the pre-spawning period in May and ranged between 16 and 26% for females. A steep drop occurred in mid-May immediately following spawning to approximately 1%. Similar reductions following spawning also occurred for males. No change was seen in GSI through August in each year, suggesting that time immediately after spawning is solely devoted to recovery and growth.
Keywords: Yellow perch, Lake Michigan, GIS.

HAWLEY, N.[1], REDDER, T.M.[2], DEPINTO, J.V.[2], and VERHAMME, E.M.[2], [1]GLERL, 4840 s. State road, Ann Arbor, MI, 48108; [2]Limnotech, 501 Avis Drive, Ann Arbor, MI, 48108.
Sediment Resuspension in Saginaw Bay.

Due to its shallow depth and orientation parallel to the prevailing wind direction, Saginaw Bay is susceptible to numerous resuspension events throughout the year that are caused primarily by surface waves. Observations of sediment resuspension were made at two locations in the inner bay during the springs of 2009 and 2010. These observations included measurements of waves, current velocities, and beam attenuation (a measure of the concentration of suspended material). The observations show a clear correlation between wave action and beam attenuation, and also show the effects of varying substrate composition. A three-dimensional model of sediment resuspension in the bay was developed and compared against the observational data. The modeled results show good agreement with the observations, although the model tends to predict peak sediment concentrations greater than those observed. The model shows that sediment resuspension events are largest during the fall when the wave heights are greatest, and also shows that during large events sediment is resuspended throughout the inner bay and over a good portion of the outer bay as well. This has important implications for water quality models, since sediment resuspension is an important factor in the annual phosphorus budget for the bay.
Keywords: Computer models, Saginaw Bay, Sediment resuspension.

HAYES-PONTIUS, E.M. and MIHUC, T.B., 101 Broad Street, SUNY Plattsburgh, Plattsburgh, NY, 12901. **Zooplankton Community Composition Before, During and After a Hydrologic Disturbance in Lake Champlain.**

In 2011 Lake Champlain experienced two major hydrologic disturbance events. Currently, little is known about how lake ecosystems respond to changes in hydrology. We sampled for zooplankton at ten sites in Lake Champlain eight to ten times a year for three years, before, during, and after 2011, a year with two extreme precipitation events. We ran NMDS ordinations to determine what shifts, if any, were occurring in zooplankton communities pre and post disturbance; a trait-based approach is used to assess the meaning of changes in composition. The south lake, hydrologically similar to a large river, exhibited no shifts in community

composition. However, four sites north of this in the main flow of the lake showed changes in composition post-disturbance, while hydrologically isolated areas in the northeast side did not. When comparing all sites within months, changes in composition were not seen in June, but were seen in July through September across all sites. Zooplankton in more hydrologically isolated areas may be less susceptible to the impacts of hydrologic disturbances. As there is an expected lag time in response, with rotifers responding to changes more quickly than the crustacean zooplankton, with longer life cycles, future years of sampling will shed light on what the full response of the zooplankton community is. *Keywords: Traits, Indicators, Community patterns, Zooplankton, Distribution patterns.*

HE, C.[1], DEMARCHI, C.[2], TAO, W.[3], and JOHENGEN, T.H.[4], [1]Department of Geography, Western Michigan University, Kalamazoo, MI, 49008-5424; [2]Department of Earth, Environmental, and Planetary Sciences, Case Western Reserve University, Cleveland, OH, 44106-7216; [3]Department of Physical Sciences and Engineering, King Abdullah University of Science and Technology, Thuwal, 23955-690, Saudi Arabia; [4]School of Natural Resources & Environment, University of Michigan, Ann Arbor, MI, 48109-1041. **An Analysis of the Nutrient and Sediment Loads Entering Saginaw Bay.**

Over the years, high nutrient and sediment loads led to the eutrophication of the Saginaw Bay in Lake Huron. To correct this state, a target Total Phosphorus (TP) load of 440 tonnes/yr was established for Saginaw Bay in 1978, successfully diminishing eutrophication. However, algal blooms and nuisance algal beach deposits have recently returned to Saginaw Bay. Here we show that the average 1997-2010 TP load to the bay was around 50% higher than the target, which was actually met only during the driest years. Our analysis indicates that the largest contribution to the load comes from the Saginaw River (more than 75% of the total load) and originates mostly in the Tittabawassee, Flint, and Saginaw Bay subwatersheds. Contribution of point sources to the total load to the bay ranges from approximately 9% in wet years to approximately 16% in dry years, while. Contributions of Retention Treatment Basins treating combined sewage outflows and stormwater is approximately 1.5 - 4.5% of the total phosphorus load. *Keywords: Watersheds, Eutrophication, Lake Huron.*

HEBERT, C.E.[1], PASHER, J.[1], WESELOH, D.V.C.[2], DOBBIE, T.[3], DOBBYN, S.[4], MOORE, D.[2], MINELGA, V.[3], and DUFFE, J.[1], [1]Environment Canada, Science and Technology Branch, Ottawa,ON; [2]Environment Canada, Canadian Wildlife Service, Downsview, ON; [3]Parks Canada Agency, Leamington, ON; [4]Ontario Ministry of Natural Resources, London, ON. **Management of Hyper-abundant Wildlife Reduces Ecosystem Impacts Facilitating Future Restoration Efforts.**

Ecosystems are at risk of catastrophic change when the biological, physical, and chemical attributes maintaining ecosystem state are altered. On Lake Erie, hyper-abundant bird populations are causing such changes to unique island ecosystems. Actions taken to address the threat of these bird populations have been island specific with culls on some islands and no management intervention on others. Ramifications of these two management approaches to island ecosystems were assessed by evaluating changes in whole island forest cover using aerial photographs taken over a maximum 16-year period. Of the three islands studied, temporal declines in forest cover were observed on all of them but trends differed among islands reflecting differences in management. On islands with no management intervention, continued degradation of island forests occurred. Where birds were culled, nest densities were reduced and extent of forest cover stabilized in recent years. Prevention of further ecosystem degradation is a prerequisite for undertaking ecological restoration activities. Continued declines on unmanaged islands may lead to irreversible ecosystem alterations. The islands studied here represent a unique opportunity to investigate inter-relationships between environmental stress, ecosystem resilience/restoration and adaptive management. *Keywords: Cormorants, Conservation, Ecosystem health.*

HECKY, R.E.[1], KATSEV, S.[1], and NOREN, A.[2], [1]Large Lakes Observatory, 2205 East Fifth Street, Duluth, MN, 55812; [2]LacCore, 500 Pillsbury Dr SE, Minneapolis, MN, 55455. **Episodic, Anomolous Organic Deposition Events in Lake Kivu: Will the Past Be Repeated?**

Lake Kivu is the largest lake (2370 km^2, max depth 485 m) in the world at risk of catastrophic degassing and is the site of increasing commercial extraction of methane from its deep waters. Because of its unusual thermohaline stratification caused by hydrothermal springs at depth, the deep waters of the lake mix slowly vertically and so trap CH_4 and CO_2. The trapped gases are above saturation at atmospheric pressure with CH_4 closest to in situ saturation. The lake is in a tectonically and volcanically active rift valley; so periodic disruption of the lake's stratification and gas release is possible. We investigated that possibility by taking several piston cores up to 9 m in length in January 2012. Preliminary results confirm the presence of at least 8 lithologically anomolous, organic-rich (>50% organic matter) layers since the middle Holocene (5000 y BP) with the most recent occurring <200 years ago. These layers have distinctive C and N isotopic composition compared to over- and underlying sediments and cannot be explained by any source of organic matter within the modern lake's water column. Although their origin is still unexplained, their presence clearly indicates that profound, repeated episodic changes in Lake Kivu have occurred and raise concern about future events. *Keywords: Africa, Lake Kivu, Paleolimnology, Isotope studies.*

HENEBRY, M.L.[1], ROSWELL, A.R.[1], FOLEY, C.J.[1], BOOTSMA, H.A.[2], CZESNY, S.J.[3], JANSSEN, J.[2], RINCHARD, J.[4], and HööK, T.O.[1], [1]Department of Forestry and Natural Resources, Purdue University, 195 Marsteller Street, West Lafayette, IN, 47907-2033; [2]School of Freshwater Sciences, Great Lakes Water Institute, University of Wisconsin-Milwaukee, 600 E. Greenfield Avenue, Milwaukee, WI, 53204; [3]Lake Michigan Biological Station, Illinois Natural History Survey, 400 17th Street, Zion, IL, 60099; [4]SUNY - The College at Brockport, 115 Lennon Hall, Brockport, NY, 14420. **Spatio-temporal Variation of Round Goby Diets, Fatty Acids, and Tissue δ13C and δ15N in Near-shore Lake Michigan, 2010 and 2011.**

Invasive species have dramatically restructured the Lake Michigan ecosystem over the past 100 years and will likely continue to disrupt this system well into the future. Understanding

trophic roles of non-native species is key to elucidating potential impacts of current and potential future invaders. Round goby were first detected in Lake Michigan in 1994, and have since increased dramatically in abundance. While past studies of round goby in Lake Michigan have primarily focused on specific regions and habitats, Lake Michigan is a large, diverse system and round goby trophic interactions may vary across regions and over time. During 2010 and 2011, we collected round goby and their potential prey at ten sites throughout Lake Michigan. At each site, we collected gobies during May, July, and September at three depths (3m, 7-9m, and 14-16m) via 2-hr bottom set, micromesh gillnets. In the laboratory, we identified and enumerated diet contents and potential benthic prey items, and homogenized gobies for subsequent fatty acid and δ13C and δ15N stable isotope quantification. Preliminary results indicate diets, fatty acids, and stable isotopes ratios of gobies vary individually (by size), seasonally, and spatially (rock v. sand substrate; east v. west Lake Michigan). *Keywords: Round goby, Invasive species, Lake Michigan.*

HENSLER, S.R.[1] and STRAKOSH, T.R.[2], [1]7806 Gale Rd., Waterford, MI, 48327; [2]2661 Scott Tower Drive, New Franken, WI, 54229. **Aquatic Invasive Species Early Detection Monitoring Program Development.**

Aquatic invasive Species (AIS) pose one of the greatest threats to Great Lakes ecosystem stability and human benefit from ecosystem services. The U. S. Fish & Wildlife Service, in collaboration with partners from the United States and Canada, is developing a new monitoring program to rapidly detect and report invasive species basin wide. This monitoring program will employ both traditional and non-traditional (e.g., environmental DNA) sampling methods to detect new AIS. Compilation of all current assessment activities in the Great Lakes has begun (e.g., sampling gears, locations, times of year) to identify gaps that may be filled by targeted AIS monitoring efforts. This task will be completed by March 2013, and preliminary sampling will occur subsequently during 2013 to help refine sampling plans and techniques. The monitoring program will be implemented during the 2014 field season and will strengthen protection of the Great Lakes from AIS. *Keywords: Biomonitoring, Invasive species, Fish.*

HER, Y., CHAUBEY, I., and FRANKENBERGER, J.R., 225 South University Street, Purdue University, IN, 47907. **Assessing the Effectiveness of Targeted Agricultural BMPs on Sediment and Nutrient Load Reduction from Upper Maumee River Watershed using SWAT.**

Intensive agricultural activities occurring in Maumee River Basin has been recognized as the largest single source of the nutrient loadings to Lake Erie. Many federal, state, and local efforts including development and implementation of TMDLs have been made to improve water quality. BMPs are common measures to reduce nutrient loadings to a waterbody, but their applicability and effectiveness are highly site-specific. This study investigated the impact of agricultural BMPs, including cover crops, no-till, riparian buffer, WASCOBs, and fertilizer and manure application, on sediment and nutrient loadings of multiple agricultural catchments in Upper Maumee River Basin draining 5,903 Km2 to Western Lake Erie. Target watersheds and the corresponding feasible BMPs were identified from field data survey and inputs of local farmers and experts. In the BMP scenario analysis, the calibrated SWAT model was used to simulate sediment and nutrient loads coming from crop and non-crop areas of the catchments. The analysis results demonstrated that the targeted agricultural BMPs can significantly reduce the loadings, and their effectiveness can vary depending on BMP types and landscape characteristics of the watersheds. The results obtained from this study are being evaluated by various watershed groups for developing watershed management plans. *Keywords: Lake Erie, Best management practices, Watersheds, Upper Manumee River, Water quality, Soil and water assessment tool.*

HILBRICH, D.J.[1], CHARLEBOIS, P.[1], TEPAS, K.[2], and PARKS, S.[3], [1]Illinois-Indiana Sea Grant, Illinois Natural History Survey, Prairie Research Institute, UIUC, c/o Chicago Botanic Garden 1000 Lake Cook Road, Glencoe, IL, 60022; [2]Illinois-Indiana Sea Grant, UIUC Extension, Liaison to U.S. EPA Great Lakes National Program Office, 77 W. Jackson Blvd. (G-17J), Chicago, IL, 60604-3511; [3]Parks Consulting Group LLC, 703 Woodbine Avenue, Oak Park, IL, 60302-1512. **Illinois-Indiana Sea Grant's Asian Carp Marketing Summit - A conversation with managers, retailers and harvesters in the Mississippi River Basin.**

Illinois-Indiana Sea Grant organized the Asian Carp Marketing Summit (ACMS) to explore the idea of using commercial markets to control wild populations of Asian carp. Various stakeholders from eight states in the lower Mississippi River Basin were invited to the ACMS for a comprehensive discussion on the opportunities and barriers for Asian carp commercial markets. During the ACMS process, stakeholders agreed on three primary markets that would be the most promising for Asian carp: 1) high-volume/low-price export, 2) high-quality/higher-priced domestic, and 3) by-product. ACMS participants also set priorities for future product development. These include, 1) demand for the product and therefore potential ability to impact wild Asian carp populations, 2) profit potential, including ability to cover costs throughout the supply chain, and 3) ease of exit once wild Asian carp population decline. Identification of these markets and priorities resulted in Illinois Department of Natural Resources-funded training opportunities for fishers on catching and proper handling of Asian carp; this training will help support a developing Chinese market for the fish. Illinois is also funding research to determine if harvesting is an effective way to reduce the environmental impacts of these fish in the Illinois River. *Keywords: Asian carp, Exotic species, Fish.*

HINCHEY MALLOY, E.[1], ADAMS, J.[1], CHERWATY-PERGENTILE, S.[2], HORVATIN, P.[1], HYDE, R.[2], RODRIGUEZ, K.[1], STADLER-SALT, N.[2], and TEPAS, K.[3], [1]U.S. Environmental Protection Agency, Great Lakes National Program Office, Chicago, IL, 60604; [2]Environment Canada, Great Lakes Issue Management and Reporting Section, Burlington, ON, L7R 4A6; [3]Illinois-Indiana Sea Grant, University of Illinois, Urbana, IL, 61801. **Overview of Great Lakes Conditions and Trends III: State of Great Lakes Landscapes and Natural Processes.**

An overview of current Great Lakes landscapes and natural processes conditions and trends will be presented. The overview is derived from indicator reports prepared by scientists from over two dozen organizations, for the 2011 State of the Lakes Ecosystem Conference (SOLEC), organized by Environment Canada and the United States Environmental Protection Agency. Status and trends to be discussed include aquatic habitat connectivity, tributary flashiness, and forest cover. *Keywords: Decision making, Ecosystem health, Indicators.*

HIRIART-BAER, V.P.[1], MOLOT, L.[2], VERSCHOOR, M.[2], and WATSON, S.B.[1], [1]Environment Canada, NWRI, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [2]York University, 4700 Keel Street, Toronto, ON, M3J 1P3. **Long term in situ photosynthetic health assessments provide meaningful insight to phytoplankton community shifts in Hamilton Harbour.**

Hamilton Harbour, a eutrophic embayment in the western end of Lake Ontario, is a designated Area of Concern since 1987. The harbour typically boasts total phosphorus (TP) concentrations over 30 µg/L, and over the last decade it has seen repeated cyanobacteria blooms during the growing season. The purpose of this study was to determine whether assays of phytoplankton photosynthetic health could 1) be related to measured environmental conditions; 2) provide information on light vs nutrient limitation; and 3) provide insight into possible environmental triggers that lead to cyanobacterial dominance in the harbour. Preliminary analysis suggests that the time of day a sample is collected has a large influence on photosynthetic health assessments and likely its interpretation in the larger context and that pulse amplitude modulation (PAM) fluorescence is largely driven by light conditions. We will present data from deployed instrumentation (phytoflash, Hobos) and weekly field sampling (profiles, nutrients and WaterPAM) in an effort to evaluate whether our physiological markers are related to phytoplankton nutrient status indicators, whether these data can provide meaningful insight on the response of phytoplankton to dynamic environmental conditions and whether triggers for cyanobacterial dominance can be proposed. *Keywords: Nutrients, Phytoplankton, Species composition.*

HITZROTH, G.H. and CHARLEBOIS, P., Illinois-Indiana Sea Grant, 1000 Lake Cook Rd, Glencoe, IL, 60022. **Great Lakes Risk Assessment Tools: Outreach for Managers, Retailers and Hobbyists.**

Part1: A needs assessment of Great Lakes invasive species managers and policy-makers was conducted. This assessment aimed to determine how managers and policy-makers 1) determined risk of aquatic invasive species in trade, 2) prohibit species, 3) perceive improvements to their state's process. Information provided by managers and policy-makers are summarized in a matrix. These data are summarized here in a few key comparisons. Part 2: Review of recently developed outreach material created from risk assessments on aquatic plants in the Great Lakes Region. The risk assessment tool was created by David Lodge at Notre Dame and Reuben Keller at Loyola University. The outreach material focuses on species used by water gardeners and determined to be of high risk for invasiveness. *Keywords: Outreach, Risk assessment, Invasive species.*

HLEVCA, B. and WELLS, M.G., University of Toronto Scarborough, 1265 Military Trail, Toronto, ON, M1C1A4. **The effect of upwelling events in Lake Ontario upon thermal variability in Toronto Waterfront embayments.**

The embayments of the Toronto harbour are subject to considerable temperature variability, which has a negative influence on the productivity of resident warm water fish population. There were frequent upwelling events in Lake Ontario, which could cause drops in temperature by more than 10^{o}C in a matter of hours, followed by a slow relaxation over several days. We report 2 years of field observations of temperature variability from within several embayments and from within Lake Ontario. Several Lake Ontario upwelling events are analyzed in order to determine their propagation patterns and their influence on the coastal embayments based on stratification strength, wind patterns, and depth of the thermocline. Statistical analysis and simple mechanistic approach are used to determine the factors that influence thermal variability in the coastal embayments. The univariate metrics determined statistically and numerically were combined to present local quantitative indices of thermal variability that characterize each of these locations. We will also discuss initial results from an acoustic fish tracking study in the harbour, and present initial analysis of the coupling between temperature and habitat use by 4 fish species. *Keywords: Littoral zone, Hydrodynamics, Lake Ontario.*

HOBRLA, R.M., EBERHARDT, R.A., and ALEXANDER, M.K., Michigan Dept. of Environmental Quality, P.O. Box 30473, Lansing, MI, 48909-7973. **From Covered Wagon to Bullet Train -- Michigan's Area of Concern Program.**

Michigan has been a leader in championing and implementing the Area of Concern program under the Great Lakes Water Quality Agreement. All or part of fourteen Areas of Concern fall within Michigan, constituting roughly half of the Areas of Concern (AOCs) on the U.S. side of the border. The Clean Michigan Initiative bond program, passed by voters in 1998, set aside twenty five million dollars for remediation of contaminated sediments. This left Michigan well-positioned to provide non-federal match for Great Lakes Legacy Act funding. As a result, there have been five sediment clean-up projects successfully implemented in Michigan with two more underway. Michigan has made it a priority to engage the public in the AOC program. Twenty years ago Michigan formed the Statewide Public Advisory Council (SPAC), an advisory group with representation from each of Michigan's 14 AOCs. Working cooperatively with the Great Lakes Commission, the MDEQ and the SPAC have sponsored a number of workshops over the years to inform and engage the public on such activities as providing education and outreach, working with the media, preparing successful grant proposals, and preparing for life after delisting. *Keywords: Great Lakes Restoration Initiative (GLRI), Area of Concern, Remediation, Contaminated sediments, Environmental policy.*

HOELLEIN, T.J. and TUREK, K., Loyola University Chicago, 1032 W Sheridan Rd, Chicago, IL, 60660. **Effects of the invasive Asian Clam, Corbicula fluminea, on nitrogen transformations in southern Great Lakes tributaries.**

The invasive Asian clam (Corbicula fluminea) is distributed worldwide, including tributaries in the southern Great Lakes. Infaunal bivalves like C. fluminea may change rates of nitrogen (N) cycling via their filtration, burrowing, and excretion. However, these effects have not been documented simultaneously or with varying N enrichment. In summer 2012, we deployed trays filled with sand, with and without clams, in 2 streams: Chicago River's North Branch, IL (urban) and Eagle Lake Outlet, MI (forested), incubated for 42 d. Clams increased ammonium (NH4+) flux and denitrification at both sites. Clams increased nitrification at the forested site only, and did not affect organic matter or exchangeable NH4+. Clams increase denitrification via delivery of nitrate (NO3-) rich water to sediments (urban), or increased NO3- via nitrification (forested). Last, we scaled all rates to 1 m2 of streambed using benthic clam density. In the forested stream, the strongest clam effect was increased NH4+ flux, but in the urban site, clams increased NH4+ flux and denitrification equally. Clams change N pools and transformations dependent upon steam trophic state, which may affect stream biofilms and N budgets. These sites are at the north edge of C. fluminea's range, so climate change could bring invasion to more Great Lakes watersheds. *Keywords: Biogeochemistry, Invasive species, Urban watersheds.*

HOLMAN, K.D.[1], LORENZ, D.J.[2], and NOTARO, M.[2], [1]Dept. of Atmospheric and Oceanic Sciences Center for Climatic Research, University of Wisconsin, 1225 West Dayton St., Madison, WI, 53713; [2]Center for Climatic Research, University of Wisconsin, 1225 West Dayton St., Madison, WI, 53713. **Influence of the Background State on Rossby Wave Propagation into the Great Lakes Region Based on Reanalysis Data and Model Simulations.**

Fluctuations in the water levels of the Great Lakes have major economical and environmental impacts. On average, warm-season changes in the water level of Lake Superior are largely driven by over-lake precipitation. Time-lag correlation maps between over-lake precipitation and 300-hPa meridional wind demonstrate that over-lake precipitation on Lake Superior is associated with a transient Rossby wave train located across the North Pacific and U.S. Results suggest that the origin and pathway of the Rossby wave train depend strongly on season and appear related to the time-mean, upper-level flow. During summer and early fall, the Pacific jet is relatively sharp and acts as a waveguide, such that Rossby wave trains traversing the Great Lakes region do not follow a great circle, rather disturbances travel along the Pacific jet. At other times of the year, the Pacific jet is relatively broad in the eastern Pacific and allows more wave activity originating in the tropics to penetrate into the mid-latitudes. Rossby wave train propagation can be significantly different in 20th Century simulations from CMIP3 models. Collectively, observations and model results show the importance of the time-mean, upper-level flow on Rossby wave propagation and on the influence of the tropics versus the extratropics on the hydroclimate of Great Lakes. *Keywords: Atmosphere-lake interaction, Precipitation, Atmospheric circulation.*

HONDORP, D.W.[1], KRUEGER, C.C.[2], BOASE, J.[3], CHIOTTI, J.[3], HOLBROOK, C.M.[1], THOMAS, M.V.[4], WILLS, T.[4], ROSEMAN, E.F.[1], MOHR, L.[5], and DROUIN, R.[5], [1]U.S. Geological Survey-Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105; [2]Great Lakes Fishery Commission, 2100 Commonwealth Blvd. Suite 100, Ann Arbor, MI, 48105; [3]U.S. Fish & Wildlife Svc.-Alpena FWCO, Waterford, MI; [4]Michigan DNR-Lake St. Clair Fisheries Research Station, 33135 South River Road, Harrison Twp., MI, 48045; [5]Ontario Ministry of Natural Resources, Wheatley, ON. **Application of acoustic telemetry to lake sturgeon restoration in the Detroit-St. Clair River System.**

This presentation will overview findings from an ongoing study of lake sturgeon populations in the Detroit-St. Clair River system that aims to provide information on habitat use by different populations as well as on population-scale movements and dispersal patterns at ecologically-relevant temporal scales. From April to early June 2012, spawning-condition adult lake sturgeon were captured in the Detroit River, lower St. Clair River, and upper St. Clair River, implanted with high-power acoustic tags with a battery life of 10 years, and then released near the capture site. Sturgeon movements between spawning, overwintering, and feeding grounds were then tracked using a network of strategically-located acoustic receivers. Analysis of movement data suggested that habitat restoration efforts in Lake St. Clair and the lower St. Clair River will potentially benefit multiple sturgeon populations within the Lake Huron to Lake Erie corridor. *Keywords: Detroit River, Lake sturgeon, St. Clair River, Migrations, Restoration.*

HORNBUCKLE, K.C., University of Iowa, College of Engineering, Iowa City, IA, 52242. **It's Not So Different: Engineering Graduate School and Career Tracks for Great Lakes Scientists.**

Great Lakes science is amazingly diverse and scientists with a wide variety of degrees and backgrounds make contributions through university, government, industry, and nonprofit research positions. While almost all these opportunities require a graduate degree, the path to the right graduate program or topic is not always clear to students, however. (It is not clear to the job holders either: sometimes we feel we just got lucky to land in a position where we can contribute to Great Lakes science.) Often the path requires a shift in subjects. For example, people with undergraduate degrees in science are great candidates for graduate school in engineering. Depending on the area of undergraduate focus, students with degrees in chemistry, geology, math, computer science, physics, and biology can reasonably consider pursuing another degree in engineering without having to start all over. This presentation will address common misconceptions about such a transition and also will highlight opportunities and advantages to people who make this shift. Specific examples of curricula and research opportunities will be discussed. *Keywords: Education, Career planning, Graduate school.*

HORVATIN, P.[1], NETTESHEIM, T.G.[1], NEWMAN, K.R.[2], MAJERUS, K.[3], BRAVERMAN, C.T.[4], GLASSNER-SHWAYDER, K.[5], KEOUGH, J.R.[6], BRATTON, J.F.[5], KOLKA, R.[7], CARL, L.M.[8], COLTON, M.[5], STOW, C.A.[5], BUNNELL, D.B.[2], STIRRATT, H.M.[9], CZARNECKI, C.A.[10], and DROTT, E.[11], [1]USEPA Great Lakes National Program Office, 77 W. Jackson Blvd, G-17J, Chicago, IL, 60604; [2]USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105; [3]USDOT, 4749 Lincoln Mall Drive, Suite 600, Matteson, IL, 60443; [4]USEPA Region 5, 77 W. Jackson Blvd, ML-10C, Chicago, IL, 60604; [5]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48108; [6]USEPA National Health and Environmental Effects Research Laboratory, 6201 Congdon Blvd, Duluth, MN, 55804; [7]USDA Forest Service - Northern Research Station, 1831 Hwy. 169 E., Grand Rapids, MN, 55744; [8]USGS Midwest Region, 1451 Green Road, Ann Arbor, MI, 48105; [9]NOAA National Ocean Service, Coastal Services Center, Chanhassen, MI, 55317; [10]USFWS Midwest Region, Bloomington, MN, 55437; [11]USACE, Great Lakes Ohio River Division, 550 Main Street, Cincinnati, OH, 45202. **An Adaptive Science-Based Framework for Great Lakes Restoration.**

A healthy Great Lakes ecosystem is strategically vital in delivering a diverse range of long term benefits to the region, the nation, and beyond. The Great Lakes Restoration Initiative (GLRI) has accomplished essential progress towards protecting and restoring the Great Lakes; however, many complex issues remain. As work continues in addressing the backlog of urgent and immediate needs, the GLRI must push ahead in confronting ever more challenging problems. These problems demand comprehensive solutions and ongoing development of innovations to advance the integration of solutions across projects, disciplines, and scales. Building upon the momentum of current GLRI success, the adaptive science-based framework for Great Lakes restoration presented here is intended to guide GLRI efforts to advance cost-effective and strategically appropriate restoration and protection actions by using the best available science and applying lessons learned from past and on-going restoration.
Keywords: Decision making, Restoration, Adaptive management.

HOUGHTON, C.J., 600 East Greenfield Ave., School of Freshwater Sciences, Milwaukee, WI, 53204. **Impacts of Round Goby on Diet and Distribution of Age-0 Yellow Perch.**

A critical step in the recruitment of age-0 yellow perch to adult populations occurs during their transition to the demersal stage. Yellow perch in Lake Michigan make this transition in late August and early September, at lengths of around 40-80 mm, where they seek out and begin feeding on benthic invertebrates associated with rocky substrates. Round gobies are now highly abundant at rocky substrates and are known to have negative impacts on benthic forage. This study used the initial spread of round gobies as a natural experiment to assess competititve interactions between age-0 yellow perch an round gobies. We found a significant shift in preferred habitat by age-0 yellow perch away from rocky substrates in the presence of round gobies correlated in changes in age-0 yellow perch diets. Round gobies also significantly altered the benthic community composition. A combination of resource depression and territoriality are likely mechanisms contributing to the displacement of age-0 yellow perch from rocky habitats.

HOUGHTON, J.S., HOUGHTON, C.J., and JANSSEN, J., 600 East Greenfield Ave., Milwaukee, WI, 53204. **Fish Colonization of an Artificial Reef along Wisconsin's Lake Michigan Coast.**

The WE Energies artificial reef (WE Reef) is located in approximately 15 meters of water 3.8 kilometers offshore of Oak Creek Wisconsin. It consists of six parallel reefs, each 30 meters wide and 180 meters long, and spaced by 30 meters. Built in 2007 and 2008, with cobble and boulder size stone, peaks of the WE Reef rise to within 8 meters of the lakes surface. Colonization of fishes at the artificial reef was assessed over a five year period, ending in 2012. Fish were sampled monthly via gill net from June to September at three sites: WE Reefs and two natural reference sites. One reference site was unaltered bottom near WE Reefs and the second was a nearby rocky reef. Yellow Perch (Perca flavescens), Burbot (Lota lota), and Longnose Sucker (Catostomus catostomus) were consistently caught in greater abundance at the WE Reef indicating that, while the artificial reefs altered the fish community, it did so in a way not comparable to the nearest natural reef. *Keywords: Fish populations, Assessments, Fisheries.*

HOUSE, G.L.[1], HECKY, R.E.[2], and GUILDFORD, S.J.[2], [1]Department of Biology, Indiana University, Bloominton, IN, 47405; [2]Large Lakes Observatory, University of Minnesota Duluth, Duluth, MN, 55812. **Photosynthetic Efficiency of Phytoplankton in Large Lakes: A Comparison Between Lake Malawi and Lake Superior.**

Measuring the photosynthetic efficiency of phytoplankton is an important step to better understand the amount of primary production that occurs through the water column of large lakes. A fast repetition rate fluorometer (FRRF) was used in both temperate Lake Superior and tropical Lake Malawi to measure water column profiles of variable chlorophyll fluorescence (Fv/Fm), a metric of how efficiently phytoplankton use absorbed light energy for photosynthesis. Despite both lakes being oligotrophic, Fv/Fm values measured in Lake Malawi (median = 0.49; n = 670) were significantly greater (Mann-Whitney U test, $p < 0.001$) than those measured in Lake Superior (median = 0.36; n = 2236). The maximum Fv/Fm values in Lake Malawi approached 0.6, close to the theoretical maximum of 0.65. It is possible that the relatively constant light conditions and warm temperatures through the year in Lake Malawi (latitude 13°S) allow phytoplankton to adapt well to their low nutrient environment compared to phytoplankton in Lake Superior (latitude 47°N) that are exposed to strong seasonal changes in both light intensity and water temperature. In both lakes, the presence of photochemical quenching of fluorescence was evident to at least 20 m, indicating that active photosynthesis still takes place at those depths. *Keywords: Phytoplankton, Lake Malawi, Lake Superior.*

HOWARD, G.E. and ROE, B.E., Ohio State University, Columbus, OH. **A Latent Class Analysis of Farmer Preferences Regarding Filter Strip Programs.**

Governments in Ohio have attempted to limit nutrient runoff in the Maumee watershed from agriculture through the establishment of Payment for Ecosystem Services (PES) programs, in which farmers are paid to implement Best Management Practices (BMPs) such as grass filter

strips. This paper seeks to understand which farmers are likely to opt into these PES programs and how farmer preferences for these programs are influenced by program attributes and farmer perceptions towards BMPs. We examine these questions using responses from a survey of Ohio farmers, where farmers choose between two PES programs and a status quo (no program) option. We allow for farmer heterogeneity using latent class analysis and find the difference among farmers is captured primarily by preferences related to the status quo choice. One class of farmers (ES) has a preference for enrolling in filter strip programs beyond what can be explained by program attributes, while the other class (O) has a preference for no program even after controlling for program attributes. Offsetting this status-quo preference in the O class would require increasing payment per acre by $183. Further, ES farmers also prefer programs that they think reduce runoff, While O farmers do not. Farmer traits are used to help identify which farmers fall into each preference class. *Keywords: Economic evaluation, Decision making, Water quality.*

HOWARD, P.H.[1] and MUIR, D.C.G.[2], [1]SRC, Inc., 7502 Round Pond Road, North Syracuse, NY; [2]Environment Canada, Aquatic Contaminants Research Division, Burlington, ON.
Identifying Persistent and Bioaccumulative Impurities, By-Products and Degradation Products of Commercial Organic Chemicals of relevance to the Great Lakes.

The Great Lakes region has always been in the forefront in terms of identification of new environmental contaminants, particularly persistent (P) and bioaccumulative (B) organic chemicals. However, the identification has been by detailed analytical chemistry and focused largely on structural analogs of previously identified compounds. With improved instrumental capabilities, the past 10 years has seen a large number of new chemicals identified, mainly halogenated organics. However, the chemicals identified represent only a small fraction of the organic chemical substances in commerce. Recently (Howard and Muir ES&T 2010) we identified 610 potential P&B chemicals from a database of 22,000 commercial chemicals used in North America. In this current study we have examined starting materials, impurities, by-products, and degradation products/metabolites of these 610 to assess whether there are additional P&B compounds associated with them. We identified 320 chemicals (39 by-products and impurities, and 282 degradation products) that could be potential P&B chemicals using computer-aided software to predict the degradation pathways in combination with the biodegradation rules of thumb. This presentation will provide examples and address the feasibility of including some of the chemicals in existing analytical procedures.
Keywords: Degradation products, Persistence, Bioaccumulation, Environmental contaminants, Organic compounds.

HSIEH, T.C.[1], TROY, C.D.[1], and HAWLEY, N.[2], [1]550 Stadium Mall Dr., West Lafayette, IN, 47907; [2]4840 S. State road, Ann Arbor, MI, 48108. **Vertical Structure and Shear Associated with Near-inertial Internal Poincaré Waves in Lake Michigan.**

Cross-thermocline mixing is an important process during the stratified period in the Great Lakes, especially in the lake interiors. Recent evidence suggests that a significant fraction of

basin-scale mixing in the world's largest lakes may actually occur in the lake interiors, away from boundaries, because of the strong shear associated with internal Poincaré waves. Several years of velocity and temperature data are examined from Lake Michigan in order to examine the vertical structure, shear, and potential instability associated with these waves. Empirical orthogonal function decomposition of the observed velocity fields show that a vertical mode 1 Poincaré wave is dominant and responsible for most of the observed thermocline shear. This analysis also identifies a unique spiraling structure associated with this mode, which is localized to the thermocline. Calculated Richardson numbers and stability analysis suggest that these waves do cause cross-thermocline mixing, but that high-resolution experiments are necessary to better quantify mixing in the interior of Lake Michigan. *Keywords: Lake Michigan, Turbulent mixing, Shear instability.*

HU, D. and HORNBUCKLE, K.C., Department of Civil & Environmental Engineering, IIHR-Hydroscience and Engineering, The University of Iowa, Iowa City, IA, 52242. **Active and passive sampling methods both illuminate the dynamics of airborne PCBs based on congener specific analysis of more than 1000 air samples.**

More than 1,000 air samples were collected using polyurethane foam based passive air samplers (PAS-PUF) and high volume active air samplers (Hi-Vol) at Chicago of Illinois, East Chicago of Indiana and Columbus Junction of Iowa in 2007-2011. PCB congener specific concentrations were determined using GC/MS/MS. PAS-PUF and Hi-Vol sampling methods are demonstrated to capture similar annual PCB concentrations and congener profiles. The average concentrations measured by PAS-PUF are, in general, slightly higher than by Hi-Vol with a factor of less than 2. Indoor PCB levels are generally 2 to 5 times higher than outdoors. Indoor and outdoor PCB profiles statistically resemble each other (cosineΘ= 0.82-0.99). In analyzed air samples, Aroclors 1242 and 1248 signals dominate mostly, but the proportions vary between locations which results in characteristic regional congener profiles. PCBs 52, 20/28, 11, 95, 31, 18/30, 8, 61/70/74/76, 3, 4, 90/101/113, 21/33, 16, 15, 110, 17, 49/69, 83/99 and 118 are individually abundant with > 2% in total percentage, and they are ranked from high to low in detection frequency in the categories of analyzed air samples. PCB11 is a non-Aroclor congener and is proved to be associated with the manufacturing of pigments or dyes as a by-product; the remaining congeners are abundant in Aroclors. *Keywords: Pollutants, Passive air samplers, PCBs, High volume active air samplers.*

HUNG, H., ALEXANDROU, N., BRICE, K., SU, K., PARK, R., MCKITTRICK, C., NORONHA, R., BAROI, M., ROSEN, J., BRODIE, S., and LANIGAN, N., Air Quality Processes Research Section, Environment Canada, 4905 Dufferin Street, Toronto, ON, M3H 5T4. **Atmospheric PBDEs and Other Flame Retardants at the Canadian Great Lakes Stations of Point Petre and Burnt Island.**

Air samples collected at two rural Canadian stations, Point Petre on the north shore of Lake Ontario and Burnt Island on northwestern Lake Huron, from Jan 2005 to Dec 2010 were analysed for polybrominated diphenyl ethers (PBDEs). Samples were taken regularly for 24 hours once every 12 days representing ~400 m3 of air. Particle and vapour phases were analyzed separately. Declining trends were observed for the 4 dominating congeners (BDE47, 99, 100 and 209) at both sites, with concentrations halving in about 3-15 years. All congeners were declining faster at Point Petre than at Burnt Island. For BDE47, 99 and 100, which were mainly found in the vapour phase, apparent seasonality was observed with higher summer concentrations. Seasonality was more random for BDE209 which is mainly particle-bound. Starting in 2009, eleven non-BDE flame retardants (FRs) were being screened for in air samples collected at both sites. Air concentrations of these FRs were lower than the PBDEs. Some compounds show higher summer concentrations corresponding to the higher temperatures, e.g. hexabromobenzene (HBB) and allyl 2,4,6-tribromophenyl ether (ATE). The concentrations of 2-ethylhexyl-2,3,4,5-tetrabromobenzoate (EHTeBB) were found to be similar to the lower end air concentrations measured at the US stations of Eagle Harbor and Sleeping Bear Dunes. *Keywords: PBDEs, Monitoring, Great Lakes basin.*

IRELAND, S.[1], CHAPMAN, D.C.[2], and ROSEMAN, E.F.[1], [1]USGS Great Lake Science Center, 1451 Green Rd, Ann Arbor, MI, 48105; [2]USGS Columbia Environmental Research Center, 4200 New Haven Rd, Columbia, MO, 65201. **Comparative Taxonomy and Description of Larval Bighead and Silver Carp with Native Great Lakes Fishes.**

Accurate identification of larval fish is important for estimating abundance and understanding ecological issues such as community structure, habitat use, and changes in distribution. This is important for invasive species such as the bighead and silver carps so that early detection can be made, allowing for abatement and response. These carps are approaching the Great Lakes where they may find suitable habitat and establish a permanent population. Currently, several large-scale larval fish surveys are underway in the Great Lakes basin that may provide early detection for these invasive fishes. We reviewed scientific descriptions of invasive carps early life history stages and consulted with experts who study carp biology. We applied information gleaned from these studies to descriptive and dichotomous key templates used in common identification guides. We documented key characters useful for identification however; identifying larval carps proves difficult as they possess many similar distinguishing characteristics of other larval fish, including many native Cyprinidae and Catostomidae species. To ensure accurate identification, we recommend obtaining preserved reference specimens, familiarization of descriptions of other larvae in your area, and developing a relationship with experts in larval fish taxonomy and carp biology. *Keywords: Life history studies, Identification, Invasive species.*

IVAN, L.N.[1], FOLEY, C.J.[2], AHMED, S.[3], CHEN, W.C.[4], TROY, C.D.[3], CHERKAUER, K.A.[4], and HÖÖK, T.O.[5], [1]CILER-SNRE, University of Michigan, Ann Arbor, MI, 48108, USA; [2]Illinois-Indiana Sea Grant, West Lafayette, IN, 47907; [3]School of Civil Engineering, Purdue University, West Lafayette, IN, 47907; [4]Department of Agriculture and Biological Engineering, Purdue University, West Lafayette, IN, 47907; [5]Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN, 47907. **Climate-change induced impacts on Lake Michigan fish habitat availability.**

Climate is the major driver of ecosystem dynamics and future changes in climate may greatly impact the availability of optimal thermal habitat for a variety of Great Lakes fishes. Reductions in optimal thermal habitat are likely to be greatest for fishes inhabiting nearshore zones, although pelagic fishes may also be impacted. We developed a bioenergetics-based growth rate potential (GRP) model for 21 ecologically or economically important species of fish and invertebrates inhabiting Lake Michigan. Temperature values were derived from SUNTANS a 3D hydrodynamic model, which was forced using down-scaled NCEP North American Regional Reanalysis data. We then calculated changes in GRP metrics for all species between current temperature regimes (2001-2010) and future increases in temperature. In addition to whole lake simulations, we also evaluated changes in temperature on a smaller spatial scale at seven nearshore transects that were spread around the lake. GRP metrics of interest included mean GRP and the number of positive GRP cells for management units. Model results will be presented to managers and policy-makers previously consulted for species selection.
Keywords: Lake Michigan, Growth rate potential, Climate change, Fish.

IVAN, L.N.[1], MASON, D.M.[2], RUTHERFORD, E.S.[2], ZHANG, H.[1], and HOFF, M.[3], [1]CILER-SNRE, University of Michigan, Ann Arbor, MI, 48108; [2]NOAA-GLERL, Ann Arbor, MI, 48108; [3]US Fish and Wildlife Service, Fisheries Program, Bloomington, MN, 55437-1458.
Assessing the risk of Asian carps establishment in the Great Lakes across productivity gradients.

Bighead and silver carps ('AC') threaten to invade the Great Lakes and disrupt aquatic food webs and fisheries. We developed a multispecies, Individual- Based bioenergetics Model (IBM) of fishes and their prey in Saginaw Bay, Lake Huron to assess the potential for AC establishment and impact on the Saginaw Bay ecosystem. The model tracks daily consumption, growth, movement and survival of four fish species and AC, and dynamic pools of phytoplankton, detritus, zooplankton, benthos, dreissenids and forage fish that serve as prey for each other and individual fishes. Once calibrated, we performed simulations to vary the initial number of Asian carps introduced and the timing of introductions to estimate the likelihood of establishment. We performed simulations at low, medium and high carp biomasses to estimate the ecological impacts of Asian carps. We performed all simulations over conditions of low, medium and high nutrient concentrations. Output from this model will be used to inform management action plans to control AC. *Keywords: Invasive species, Ecosystem modeling, Lake Huron.*

JACKSON, P.R., U.S. Geological Survey, 1201 W. University Ave., Suite 100, Urbana, IL, 61801. **Circulation and Mixing in Nearshore Lake Erie in the Vicinity of Villa Angela Beach and Euclid Creek, Cleveland, Ohio.**

Villa Angela Beach along the Lake Erie shoreline is adjacent to Euclid Creek, a small stream susceptible to combined sewer overflows on a regular basis. Concerns over high *E. coli* concentrations along this beach have led to synoptic mapping of the nearshore mixing zone in an attempt to gain insight into mixing processes, circulation, and contaminant transport. Integrated synoptic mapping was performed during low flow on Euclid Creek on August 29-32, 2011 and September 11-12, 2012 by the U.S. Geological Survey. An autonomous underwater vehicle and boat equipped with an acoustic Doppler current profiler were used in the survey. Spatial distributions of water quality and nearshore currents suggest the mixing zone surrounding Villa Angela Beach is dynamic and highly variable. Nearshore circulation along Villa Angela Beach appears to be primarily wind-driven, but can decouple from local wind forcing during periods of dominant regional circulation. Observed circulation patterns show that Euclid Creek water, and the contaminants therein, may be trapped in a recirculation along Villa Angela Beach formed by interaction of nearshore currents with shoreline structures. In addition, at least one persistent anomaly in water quality was present along Villa Angela Beach in 2011, possibly suggesting the presence of groundwater inflows. *Keywords: Water currents, Nearshore, Water quality, Beach health, Lake Erie.*

JACOBS, A.I. and KELLER, R.P., Department of Environmental Science, Loyola University Chicago, 6460 N. Kenmore, Chicago, IL, 60660. **Aquatic Invasive Species in Illinois: Inventory, Analysis of Spread, and Relation to Great Lakes Aquatic Invasive Species Management.**

The state of Illinois straddles the divide between the Laurentian Great Lakes and Mississippi drainages. Several non-native species have already breached this divide by traveling through Illinois, and the goal of preventing future species movements has become an important regional and continental priority. Despite the importance of Illinois in the spread of non-native species, there is no statewide database describing the known locations of non-native species. Instead, many institutions and individuals hold some amounts of data. This hinders conservation planning and management because many of these datasets are not readily available. It also hinders predictions of future invasions because it is difficult to analyze past patterns of invasion. We have assembled a database of known occurrences of non-native aquatic species in Illinois. These locations have been mapped to determine the species currently in the state, waterbodies that are most highly invaded, and waterbodies that may be at highest risk of future invasion. Additionally, we have determined the subset of species that pose a high risk of moving between the Great Lakes and Mississippi drainages. This information will support efforts to slow rates of invasion across North America. *Keywords: Invasive species, Risk assessment, Management.*

JACOBS, G.J.[1], MADENJIAN, C.P.[2], BUNNELL, D.B.[2], WARNER, D.M.[2], and CLARAMUNT, R.M.[3], [1]US Fish and Wildlife Service Northeast Fishery Center, 227 Washington Avenue, Lamar, PA, 16848; [2]US Geological Survey Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105; [3]Charlevoix Fisheries Research Station, Michigan Department of Natural Resources, 96 Grant Street, Charlevoix, MI, 49720. **Chinook Salmon Foraging Patterns in a Changing Lake Michigan.**

We characterized Chinook Salmon diets, prey species selectivity, and prey size selectivity between 1994-1996 and 2009-2010 time periods in Lake Michigan. In Lake Michigan during 1994-1996, there were larger Alewives, relatively more abundant alternative prey species, fewer Chinook Salmon, and fewer invasive species than in the years 2009-2010, which were instead characterized by smaller Alewives, fewer alternative prey, higher abundance of Chinook Salmon, a firmly established nonnative benthic community, and reduced abundance of Diporeia. In 1994-1996, Alewife represented a smaller percentage of Chinook Salmon diets than in 2009-2010, when Alewife comprised over 90% of Chinook Salmon diets, possibly due to declines in alternative prey fish populations. The size of Alewives eaten by Chinook Salmon also decreased between these two time periods. For the largest Chinook Salmon in 2009-2010, the average length of Alewife prey was nearly 50 mm shorter than in 1994-1996. We suggest that changes in the Lake Michigan food web may have contributed to the relatively low abundance of large Alewives during the late 2000s by heightening the effect of predation from top predators like Chinook Salmon, which have retained a preference for Alewife and now forage with greater frequency on smaller Alewives. *Keywords: Diets, Salmon, Alewife.*

JAKUBISON, C.J. and PANGLE, K.L., 217 Brooks Hall Central Michigan University, Mount Pleasant, MI, 48859. **Improving laboratory observations of aquatic organisms in turbid environments using DIDSON.**

Advancements in sonar technology have led to new possibilities for aquatic biologist. For example, dual-frequency identification sonar (DIDSON) can accurately observe and quantify behavioral interactions of organisms in the field, even under extremely turbid conditions. Extension of DIDSON for use in laboratory experiments is still, however, an open question, as this type of research application is unprecedented. The goal of our study was to explore the utility of the DIDSON under a range of practical laboratory conditions. We focused on the ability of DIDSON to detect and accurately measure the swimming speed of different sized targets in aquaria of different sizes and materials (i.e., glass, fiberglass, cement), at different depths, distances, and angles, and with different obstructions (i.e., standpoints and mesh screening). In general, DIDSON was remarkably robust under the different combinations of laboratory conditions, but there were clearly benefits for employing certain configurations (e.g., improved signal-to-noise ratio in cement tanks). Based our results, we i) found that DIDSON was clearly capable of capturing behavioral interactions in a laboratory setting, and ii) were able to put forth a list recommendations for standardized methods that may aid future use of DIDSON in laboratory experiments. *Keywords: Turbidity, Acoustics, Fish behavior.*

JAMEEL, M.Y.[1], BOWEN, G.[1], WILSON, A.E.[2], HÖÖK, T.O.[3], STEIN, S.R.[3], ROSWELL, C.R.[3], and GRIMM, E.F.[4], [1]Department of Geology & Geophysics,Frederick Albert Sutton Building, University of Utah, 115 S 1460 E, Salt Lake City, UT, 84112; [2]Department of Fisheries and Allied Aquacultures, 203 Swingle Hall, Auburn University, Auburn, AL, 36849; [3]Department of Forestry and Natural Resources, Purdue University, 195 Marsteller Street, West Lafayette, IN, 47907; [4]School of Civil Engineering,, Purdue University, 550 Stadium Mall Drive, West Lafayette, IN, 47907. **Biological and Water Quality characterization of Lake Michigan River Plume.**

Riverine inputs form a major source of nutrients for the Great Lakes, and in some cases river plumes have been shown to be a hotspot for the recruitment of larval and juvenile fish. As part of an effort to characterize the biological and water quality characteristics of Lake Michigan river plumes we measured water isotope ratios in the plumes of several rivers (St. Joseph, Trail Creek, Muskegon and Grand River) in 2011 and 2012. Distinct stable isotope compositions ($\delta^{18}0$ and δD) were observed for lake and river water at each site. A linear mixing model was used to calculate the fraction of river water at five different locations in the lake near each river mouth. The data revealed a varied range of river water influence, both spatially and temporally, at each site. Whereas for St. Joseph there was a defined river plume, the size of which decreased from summer to fall in association with a decrease in flow rate, Trail Creek was characterized by lower flows and a minimal plume throughout most of the study interval, and during a few sampling events we identified backflow from the lake to the river. River water mixing ratios were strongly correlated with water quality data for most locations and times, providing information on the roles of physical mixing and biochemical processes on nutrient input to Lake waters. *Keywords: Lake Michigan, Biogeochemistry, Data acquisition.*

JAMES, M.D. and AUSTIN, J.A., 2205 E 5th Street, Duluth, MN, 55812. **Sustained Autonomous Profiling in Lake Superior.**

In October 2012, a successful test deployment of one of two new WET Labs autonomous moored profilers (AMP) was completed in western Lake Superior. During its 11-day deployment, the profiler repeatedly measured profiles of conductivity, temperature, dissolved oxygen, nitrate, backscatter and PAR as well as fluorescence measurements of chlorophyll-a, CDOM, phycoerythrin and phycocyanin. The profiler's acoustic Doppler current meter was inoperable during the extended test deployment. With limited shore-side intervention, profiles were made roughly every two hours from 0-50m for a total of 120 profiles. Communications via Iridium satellite were regularly established during surfacings, providing the opportunity to monitor or alter the profiler's mission. The mission's regular two-hour profiling interval allowed for the observation of strong inertial oscillations of the thermocline. This thermocline excursion was reflected, among other fields, in the DO record. Future missions are expected to produce more extensive data sets which should prove to be a significant asset to the current observing array. Longer, multi-week deployments are being planned, beginning in the spring of 2013, including the possibility of over-winter operation. *Keywords: Data acquisition, Autonomous Platforms, Lake Superior, Observing systems.*

JANSSEN, J.[1], SITAR, S.[2], and HANSEN, T.[1], [1]School of Freshwater Sciences, University of Wisconsin-Milwaukee, Milwaukee, WI, 53204; [2]Marquette Fisheries Research Station, Michigan Department of Natural Resources, Marquette, MI, 49855. **Deepwater Lake Trout Spawning Habitat: a River Runs Through It?**

The conceptual model for lake trout spawning is based on shallow water spawning fish, with sloping cobble substrate and a wind-fetch sufficient to generate a "just right" wave surge to ventilate eggs without disturbing the substrate. This model must break down at some depth, because the depth of wave surge is limited. For Lake Michigan's Mid-Lake Plateau we collect lake trout eggs in patch reefs atop the plateau that are likely relict glacial drumlins and eskers. It appears to be important that these patch reefs be near a dropoff so that hydrodynamic edge effects of accelerating water flow provide a ventilating current. In a more general spawning habitat model it may be that slope per se is not a critical factor, but a physical structure that accelerates water flow is critical. We have found one potential example of this more generalized model in Lake Superior at a granite reef with near vertical flanks. There was scoured clean cobble at its base. This cobble had no slope so the accelerated flow was due to the adjacent vertical granite wall. We saw lake trout but did not validate egg deposition. If the critical factors for deepwater spawning lake trout are accelerated water flows and clean cobble then physical conditions for spawning habitat mabe more similar to stream-spawning salmonines.
Keywords: Lake Michigan, Habitat, Lake trout, Recruitment.

JANTUNEN, L.[1], STRUGER, J.[2], BACKUS, S.M.[2], KRAFT, J.[2], and HUNG, H.[3], [1]Environment Canada, 6248 Eighth Line, Egbert, ON, L0L 1N0; [2]Environment Canada, Burlington, ON; [3]Environment Canada, 4905 Dufferin Street, Toronto, ON, M3H 5T4. **Organophosphate Flame Retardants in Southern Ontario Tributaries and Precipitation.**

Monthly water samples for organophosphate flame retardants (OPs) were collected between October 2010 and December 2011 from tributaries in southern Ontario that drain into lakes Ontario, Erie and Huron. Tributaries included urban, suburban, rural and agricultural rivers, streams and creeks. Compounds identified in this study were: triphenyl phosphate (TPP), tris(2-chloroethyl) phosphate (TCEP), tris(2-chloroisopropyl) phosphate (TCPP), tris(1,3-dichloro-2-propyl) phosphate (TDCPP) and tris(2-butoxyethyl) phosphate (TBEP). OP compounds detected in tributaries were on average (ng/L): TBEP (307) > TCPP (169) > TCEP (107) > TCDPP (17) ≈ TPP (14). All OP compounds showed the same trend with highest concentrations in the urban tributaries that receive water from combined storm/sewer lines and possibly cracked sewer lines in Toronto and lowest concentrations were at rural sites. Rain samples were also collected at two rural sites in May to October 2011, TCEP had the highest concentration, averaging 102 ng/L. There was very different pattern of OPs in the rain, dominated by TCEP, compared to the tributaries, dominated by TBEP and TCPP and ambient air over the Great Lakes, dominated by TCPP and TCEP. This study showed that urban tributaries are a significant source of OPs to the Great Lakes. *Keywords: Environmental contaminants, Tributaries, Organophosphate flame retardants, Urban watersheds, Priority pollutants.*

JAVONOVIC, C.[1], ROSEMAN, E.F.[2], FIELDER, D.G.[3], HÖÖK, T.O.[4], and SCHAEFFER, J.S.[2], [1]University of Michigan School of Natural Resources and Environment, 400 E. University, Ann Arbor, MI, 48105; [2]USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105; [3]MDNR Alpena Fisheries Research Station, 160 E. Fletcher, Alpena, MI, 49707; [4]Purdue University, West Lafayette, IN, 47907. **Are walleye driving prey fish dynamics in Saginaw Bay?**

Walleye resurgence in Saginaw Bay may be placing heavy predatory demand on prey fish in addition to existing environmental stressors. We examined walleye diets during 2009-2011 using over 2200 fish collected by volunteer anglers, additional diet and prey data from fishery independent surveys, and a bioenergetics model to examine their role in the Saginaw Bay ecosystem, with emphasis on whether walleye predatory demand was sufficient to influence yellow perch recruitment. Modeled walleye consumption during 2009 suggested that walleye consumed a substantial proportion of age-0 yellow perch, with most predatory demand coming from age-2 and younger walleyes that were too small to harvest. Data from subsequent years indicated that yellow perch became even more important in walleye diets; thus high predatory impacts on yellow perch may be chronic. Walleye consumed other species such as round goby and emerald shiner, but yellow perch dominated diets during both 2010 and 2011. High predatory demand may explain propensity for walleye to emigrate Saginaw Bay, and we hypothesize that walleye predation may underlie chronically low alewife recruitment in Lake Huron. Additionally, main basin walleye have a very different diet than those in Saginaw Bay, and likely interact with offshore salmonines. *Keywords: Yellow perch, Walleye, Fish diets, Prey fish, Lake Huron.*

JERDE, C.L., WITTMANN, M.E., and LODGE, D.M., University of Notre Dame, Department of Biological Sciences, Notre Dame, IN, 46556. **Modeling Allee effects due to sterile grass carp introductions: An unplanned experiment in the Laurentian Great Lakes.**

Since the 1970, sterile grass carp have been transported throughout the United States as a means of macrophyte control, while keeping grass carp from becoming established and invasive. However, recent wild captures of reproductively viable, diploid grass carp in Great Lakes' rivers indicate there is some risk of population growth and establishment. Using a hierarchical, stochastic population model, we estimate the probability of population establishment as a function of the population abundance, ratio of sterile to reproductively viable individuals, survival, and juvenile recruitment. In the absence of sterile individuals, the mating behavior of grass carp results in a weak Allee effect, and the probability of establishment is driven primarily by demographic stochasticity. However, if sterile individuals dominate a population, the Allee effect becomes more influential and the probability of establishment at low population size approaches zero. Consequently, the presence of wild, but sterile grass carp, which accidentally escaped into the wild, is acting as a barrier to grass carp establishment *Keywords: Invasive species, Model studies, Management.*

JESSEE, N.L., SHUCHMAN, R.A., RAYMER, Z.B., SAYERS, M.J., FAHNENSTIEL, G.L., BROOKS, C.N., and GRIMM, A.G., Michigan Tech Research Institute, 3600 Green Ct., Ste. 100, Ann Arbor, MI, 48105. **Current and Historical Monitoring of Saginaw Bay Water Quality Using Satellite Remote Sensing.**

Utilizing a variety of sources of satellite based imagery, an extensive body of derived remote sensing products have been generated for the Saginaw Bay region of Lake Huron. Satellite-based sensors such as Landsat, CZCS, SeaWiFS, MODIS, and MERIS form a continuous source of environmental observations dating back to the mid 1970s. With different spatial, spectral and temporal scales, each satellite sensor provides an important piece to the detailed time series of remote sensing information derived for Saginaw Bay. Remote sensing products include bottom type mapping, water clarity, lake surface temperature, sediment plume extent, primary productivity, land cover, and concentrations of chlorophyll, dissolved organic carbon, and suspended minerals. Together these derived remote sensing products can help a variety of stakeholders including government agencies, scientists, local resources managers, and the public track recent and historical changes in Saginaw Bay and help monitor the impacts of restoration efforts. *Keywords: Remote sensing, Time series, Water quality.*

JETOO, S.[1] and THORN, A.[2], [1]McMaster University, Hamilton, ON, L8S 4M9; [2]Ryerson University, Toronto, ON. **The Great Lakes Futures Project: Governance and Geopolitics as Drivers of Change in the Great Lakes-St. Lawrence Basin.**

This paper provides an overview of governance and geopolitics as drivers of change in the Great Lakes-St Lawrence Basin. It separates regional conditions into two themes, water quantity and water quality, tracing historical trends over the past fifty years. This study of the history of Great Lakes governance and geopolitics reveals recurrent themes that impact the sustainability of the resource: institutional fragmentation, the changing relationship between federal and sub-national levels of government in Canada and the United States, governance capacity, and the impact of geopolitics on governance. These themes are explored to imagine the future under two potential scenarios: a best case scenario of a sustainable Great Lakes and St. Lawrence River Basin with solid governance in place, and a worst case scenario of poor governance that contributes to ecological disaster. This paper aims to distil governance in the Great Lakes-St. Lawrence Region with the goal of increasing understanding of governance as a driver in this region. *Keywords: Environmental policy, Governance driver, Policy making, Geopolitics, Great Lakes basin, Futures.*

JOHNSON, H.E.[1], HAACK, S.[1], BRENNAN, A.K.[1], and U'REN, S.J.[2], [1]6520 Mercantile Way, Ste 5, Lansing, MI, 48911; [2]13272 S. West Bay Shore Drive, Traverse City, MI, 49684. **Storm Drains as a Potential Reservoir for Pathogens.**

Many beaches in the Great Lakes are influenced by urban storm drains that deliver sediment, pathogens, and other urban pollutants to beaches where recreational contact with pollutants could potentially occur. Sampling locations were selected based on the proximity of a

storm drain to a recreational beach at two beaches in northern Lower Michigan, and one beach in the Upper Peninsula of Michigan. From August 2010 to July 2012 38 samples from storm drains and 33 samples from beaches were collected. Samples were filtered and enumerated for the fecal indicator bacteria *Escherichia coli* (*E. coli*), *Enterococcus* and the common skin bacteria *Staphylococcus*. Samples were further analyzed for a total of fourteen bacterial pathogen virulence and antibiotic resistance genes using end-point polymerase chain reaction (PCR). Thirteen of the fourteen genes were detected in both storm drain discharge and the associated recreational water. As many as twelve genes were detected on days when *E. coli* concentrations met the EPA Beach Action Value of 235 colony forming units per 100 mL. This poster presentation will focus on providing important and relevant information to water resource managers seeking to remediate storm drain discharge at recreational beaches.
Keywords: Urbanization, Storm Drains, Microbiological studies, Pathogens.

JOHNSON, L.T., BAKER, D.B., RICHARDS, R.P., ROERDINK, A.R., CONFESOR, R.B., KRAMER, J.W., EWING, D.E., and MERRYFIELD, B.J., National Center for Water Quality Research, Heidelberg University, Tiffin, OH, 44883. **The Influence of Land Use and Hydrology on Annual Nutrient Yields in Ohio Watersheds.**

To better understand factors influencing watershed nutrient and sediment export, we examined 5-year average annual yields from 11 Midwestern watersheds with varying land use and hydrology. Annual yields of suspended sediments (SS), total phosphorus (TP), dissolved reactive P (DRP), nitrate, and chloride (Cl) from hydrologically stable agricultural watersheds (Raisin and Tiffin R) were lower than flashy agricultural watersheds (Portage, Maumee, and Sandusky R), but similar to forested watersheds (Muskingum and Grand R). Annual yields from these hydrologically stable agricultural watersheds were also lower than mixed agriculture/urban watersheds (Great Miami and Scioto R). Chickasaw Cr had 2-16 times higher DRP and nitrate annual yields than the other watersheds, reflecting widespread application of manure fertilizer. Urbanization had a strong influence in the Cuyahoga R where runoff, SS, and Cl yields (57cm, 1264 kg/ha, and 890 kg/ha, respectively) were the highest compared to other watersheds (mean: 43cm, 590 kg/ha, and 126 kg/ha, respectively). Thus, general land use classification, particularly agriculture, can have highly variable annual yields dependent on watershed hydrology. Annual yield is a useful metric to identify subwatersheds for management to meet target nutrient loads to downstream waterbodies, such as Lake Erie. *Keywords: Nutrients, Watersheds, Comparison studies.*

JOHNSON, N.J., Urban Waters Federal Partnership/Save the Dunes, 444 Barker Road, Michigan City, IN, 46360. **The Future of Rivermouths.**

Visions change with time and knowledge. In Northwest Indiana, there are many outlooks on how rivermouths can and should be utilized. This portion of the symposium will go through what visions have been created in the last 15 years for local rivermouths and where education and outreach efforts have brought us today. *Keywords: Water quality, Education, Public participation.*

JOHNSON, T.C.[1], WERNE, J.P.[1], HALBUR, J.[1], and ABBOTT, A.[2], [1]Large Lakes Observatory, University of Minnesota Duluth, Duluth, MN, 55812; [2]College of Earth, Ocean and Atmospheric Sciences, Oregon State University, Corvallis, OR. **A 1.2 million year record of rainfall and temperature from Lake Malawi.**

The Lake Malawi Drilling Project obtained cores from 11º S latitude in 600 m water depth, to a depth of 384 meters below lake floor, representing the past 1.2 million years of environmental history. The age model is based on radiocarbon dates in the upper part of the record, an Ar/Ar date on a 921 ky tephra, and subtle, paleomagnetic reversals that are based solely on inclination from this low latitude site. The hydrological history of the lake is derived from the presence or absence of endogenic calcite, abundance of organic matter, ostracod assemblages (when present), and δ13C of long-chain n-alkanes derived from terrigenous plant leaf wax. The paleotemperature record is based on TEX86, an index based on the molecular structure of tetraether compounds derived from prokaryotic Thaumarchaea that live in the upper water column. The last 400,000 years have been substantially different from the earlier part of the record: glacial-interglacial shifts in temperature with a ~100,000 cycle have been more pronounced, and the Malawi basin has exhibited substantially wetter conditions since the Mid-Pleistocene transition (600 - 900 ka). This shift to wetter conditions in the Lake Malawi basin runs counter to an overall trend in East African climate towards drier conditions over the past 3 Ma. *Keywords: Paleolimnology, Africa, Climates.*

JOSHI, S.J.[1], SMITH, J.P.[2], KRAMER, E.L.[2], and RITZENTHALER, A.A.[2], [1]Michigan Sea Grant, 4840 S State Rd, Ann Arbor, MI, 48108; [2]Cooperative Institute for Limnology and Ecosystem Research, University of Michigan, 4840 S State Rd, Ann Arbor, MI, 48108. **Communicating near shore water quality data with stakeholders using an interactive website.**

In an effort to develop an improved near-shore water quality forecasting model in the Great Lakes, an intensive monitoring program was established in Lake St. Clair. As a government agency, NOAA has the responsibility to make all data collected and/or analyzed publically available. A pilot, single page website was launched last year in order to fulfill this responsibility. Presenting only tabular data, and providing limited textual explanation, users found that while data was being made available to them, it was not being presented in a meaningful way. To make the website more user-friendly for end users and stakeholders who will be accessing and using the water quality data, we have launched a revised site, which incorporates end user feedback we received, to more effectively reach a wide audience of stakeholders including lake front property owners, boaters, anglers, beach managers, government officials, restoration project managers, and the GLRI community at large. A new website, which is no longer limited to the site on Lake St. Clair, incorporates user friendly text, pictures, clickable maps, and graphs in order to communicate near shore water quality data to multiple audiences. Here we present the new website and demonstrate/discuss various features including interactive graphs, river plume animation, and data download. *Keywords: Decision making, Stakeholder communication, Human health.*

JUETTE, P.M., KARATAYEV, A.Y., and BURLAKOVA, L.E., Great Lakes Center, Buffalo State College, 1300 Elmwood Ave., Buffalo, NY, 14222. **Reconstruction of dreissenid biomass and distribution dynamics in Lake Erie.**

Dreissena polymorpha (zebra mussel) and *Dreissena rostriformis bugensis* (quagga mussel) have been important invaders in the Laurentian Great Lakes since their introduction in the mid 1980's. While both species have been explosively successful in the Great Lakes, research and observation suggest that the density and distribution of these species has varied greatly since the initial invasion. Many surveys have already been conducted on Lake Erie, however the methodology between studies differs significantly. Past studies' methods for evaluating dreissenid biomass include measuring dreissenid total wet weight on site, measuring wet weight after freezing and thawing, measuring dry weight, and measuring ash-free dry weight. This discrepancy in methodology has prevented viewing all present data on invasive dreissenid biomass in Lake Erie collectively. The purpose of this study was to empirically determine ratios that make such comparisons possible and present a clearer picture of the changes that have occurred over time in the populations of both invasive species. These conversion ratios will be presented, along with new collective estimates of how dreissenid biomass has changed over time in Lake Erie. *Keywords: Benthos, Lake Erie, Dreissena.*

KANE, D.D.[1], CONROY, J.D.[2], RICHARDS, R.P.[3], BAKER, D.B.[3], THOMAS, M.A.[4], and CULVER, D.A.[5], [1]Division of Natural Sciences and Mathematics, Defiance College, Defiance, OH, 43512; [2]Division of Wildlife, Ohio Department of Natural Resources, Hebron, OH, 43025; [3]National Center for Water Quality Research, Heidelberg University, Tiffin, OH, 44883; [4]F. T. Stone Laboratory, Put-In-Bay, OH, 43456; [5]Department of Evolution, Ecology, and Organismal Biology, The Ohio State University, Columbus, OH, 43212. **HABs, Hypoxia, and History: The Re-Eutrophication of Lake Erie.**

The recent re-eutrophication of Lake Erie has been most evident from the massive harmful algal blooms (HABs) that have been a recurrent phenomenon for close to two decades, especially in the western basin (but also in the central basin). Areas of hypoxia/anoxia in the western, central, and Sandusky basins have also been frequent during this time period. Herein we will discuss trends in HABs (cyanobacterial seasonal average biomass) and in dissolved oxygen concentrations with an approximately decade worth of data for each and link these trends to stressors external to the lake, including nutrient loading and weather conditions. We will also put these recent observations into an historical context by using data collected from the mid-to-late 20th century. Finally, we will discuss some of the implications for management and restoration of the lake to a less eutrophic state and how some stressors that have lead to Lake Erie's re-eutrophication may be remediated, while others are beyond the realm of the management community. *Keywords: Harmful algal blooms, Oxygen, Eutrophication.*

KAO, Y.C.[1], MADENJIAN, C.P.[2], BUNNELL, D.B.[2], LOFGREN, B.M.[3], and PERROUD, M.[4], [1]Univ. of Michigan, School of Natural Resources and Environment, 440 Church Street, Ann Arbor, MI, 48109; [2]USGS, Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105; [3]NOAA, Great Lakes Environmental Research Laboratory, 4840 S. State Road, Ann Arbor, MI, 48108; [4]Univ. of Michigan, Cooperative Institute for Limnology and Ecosystems Research, 4840 S. State Road, Ann Arbor, MI, 48108. **The Effects of Climate Change on the Growth and Consumption by Salmonines in Lakes Michigan and Huron.**

We used a bioenergetics modeling approach to investigate the effects of climate change on the growth and consumption by Chinook salmon, lake trout, and steelhead in Lakes Michigan and Huron. We ran bioenergetics simulations across age-classes and across all four seasons under different scenarios of prey availability. When prey availability was not limited, our results showed the growth and consumption by these salmonines will increase substantially in the projected future climate regime due to the increased capacity of prey consumption. When prey consumption remained constant into the future, our results showed the growth of these salmonines usually decreased but, in some cases, increased slightly because the increased metabolic cost was compensated by the decreased waste loss. Projected changes in the growth and consumption by these salmonines primarily occurred in spring and fall when prey energy densities are relatively high. Such seasonality in prey consumption will benefit the growth through increasing average prey energy density in diets for these salmonines. Lastly, we predicted lake trout and steelhead will be better adapted to the warming climate than Chinook salmon; and a 10% increase in prey availability would be sufficient for all these three salmonines to maintain current growth in the future climate regime. *Keywords: Lake Michigan, Salmonines, Climate change, Lake Huron.*

KARATAYEV, A.Y.[1], BURLAKOVA, L.E.[1], PENNUTO, C.M.[1], CIBOROWSKI, J.J.H.[2], KARATAYEV, V.A.[3], JUETTE, P.M.[1], and CLAPSADL, M.[1], [1]Great Lakes Center, Buffalo State College, 1300 Elmwood Ave., Buffalo, NY, 14222; [2]University of Windsor, 401 Sunset Ave., Windsor, ON, N9B 3P4; [3]Cornell University, 216 Stimson Hall, Ithaca, NY, 14853. **Twenty Five Years of Changes in *Dreissena* spp. Populations in Lake Erie.**

Lake Erie, due to its morphometry and the longest history in North America of colonization by both *Dreissena polymorpha* (zebra mussel) and *D. r. bugensis* (quagga mussel), is a prime model for investigating population dynamics and interspecies competition among dreissenids. We found that dreissenid distribution in Lake Erie varies significantly depending on the time since the initial invasion, depths, and lake basin morphometry. Quagga mussels were found at all depths and in all basins, while zebra mussels were limited to shallow depths. Zebra and quagga mussels have had a clearly opposite trend in their dynamics in the central and eastern basins, resulting in an almost complete replacement of zebra mussels with quagga mussels in the deep parts of the lake. In the shallowest western basin, zebra mussels formed more than 50% of the combined dreissenid density even after > 20 years of coexistence. This provides strong evidence that, even in lakes as large as Lake Erie (or at least its western basin), zebra mussels may sustain a significant presence for years to come without being displaced by quagga mussels. *Keywords: Dreissena, Invasive species, Lake Erie.*

KARATAYEV, V.A.[1], KARATAYEV, A.Y.[2], BURLAKOVA, L.E.[2], and RUDSTAM, L.G.[1], [1]Cornell University, Ithaca, NY, 14853; [2]Great Lakes Center, Buffalo State College, 1300 Elmwood Ave, Buffalo, NY, 14222. **Eutrophication versus Dreissena: a Century of Change in the Lake Oneida's Molluscan Community.**

Of all the environmental changes faced by freshwater ecosystems, cultural eutrophication and invasive species have probably had the strongest impacts, and both are commonly associated with strongly negative impacts on native communities. Over the past century, these two factors have had profound impacts on Lake Oneida and its diverse molluscan community. We used historical data and our 2012 survey of the lake's molluscs to pair the impacts of eutrophication and the invasion of *Dreissena* with the dramatic changes observed among the lake's molluscs. We attribute the strong decline in density and diversity of gastropods to eutrophication, while the extirpation of unionids from the lake has likely been the result of the invasion of zebra mussels. However, we have also detected a recent recovery in the lake's gastropod community, likely as a result of the increase macrophyte and periphyton abundance associated with the ecosystem-wide effects of *Dreissena*. Therefore, while eutrophication often has negative impacts on benthic communities, invasive filter-feeders like dreissenids have species specific effects, on native mollusc, including direct negative on unionids and indirect positive on gastropods.
Keywords: Eutrophication, Dreissena, Biodiversity.

KARSIOTIS, S.I., SULLIVAN, T.J., and STEPIEN, C.A., Lake Erie Center, 6200 Bayshore Road, Oregon, OH, 43606. **Genetic Structure of Smallmouth Bass across North America: Patterns from Two Genomes.**

Analysis of population genetic relationships reveals the signatures of ongoing processes such as spawning behavior and migration, and historical events such as vicariance and climate change. This study provides a dual genome analysis of population genetic patterns of 279 spawning smallmouth bass across 13 locations-including all Great Lakes and the Mississippi, Ohio, St. Lawrence, and Hudson rivers -using eight nuclear DNA microsatellite loci and mtDNA cytochrome b sequences. Null hypotheses are (1) genetic variation is not significantly partitioned among watersheds, lakes, rivers, and basins and (2) there is not a significant difference between mitochondrial and nuclear DNA patterns. Results discern genetic demarcations across the range, and pronounced differences even among closely spaced riverine sites. Population genetic origins trace to recolonization patterns from glacial refugia, which have been maintained through present day. Relationships follow a broadscale genetic isolation by geographical distance pattern, but those within lakes and proximate river sites do not. The latter appear influenced by homing and site fidelity. *Keywords: Genetics, Fish populations, Fish management.*

KATSEV, S. and LI, J., Large Lakes Observatory, University of Minnesota Duluth, 2205 E. 5th St., Duluth, MN, 55812. **Carbon and Nutrient Cycling in Sediments of Lake Malawi.**

Like other East African Great Lakes, Lake Malawi is experiencing warming of its surface waters, which is expected to affect the strength of its stable vertical stratification and nutrient fluxes from deep waters to the photic zone. It also responds to changes in land use around the

lake that modify fluxes of essential nutrients such as phosphorus and affect the carbon cycle. We will present preliminary results from 2011-2012 investigations of sediment cores taken from several locations along the length of Lake Malawi. They suggest that the rates of anaerobic carbon mineralization and the efficiency of carbon recycling in these sediments are similar to those in other tropical lakes, such as Lake Kivu, and not significantly different from those in temperate large lakes, which enables cross-system comparisons. We also characterize the dominant pathways of nutrient cycling in these sediments, their fluxes across the sediment-water interface, contributions to lake-wide nutrient budgets, and potential sensitivity to future changes. *Keywords: Africa, Geochemistry, Sediments.*

<u>KATSEV, S.</u>[1], HECKY, R.E.[1], and MACINTYRE, S.[2], [1]Large Lakes Observatory, University of Minnesota Duluth, Duluth, MN, 55812; [2]Department of Ecology, Evolution, and Marine Biology, University of California Santa Barbara, Santa Barbara, CA. **Warming of Lake Kivu.**

The 450 m deep Lake Kivu is stratified by salinity and has an anomalous temperature distribution, with temperature minimum at about 80 m depth. Deep heat sources cause temperature to increase below, and heat from these waters can be removed to the atmosphere only when surface mixing extends down to the depth of temperature minimum. Data from moored temperature recorders indicate that mixing did not reach that depth in 2011 and 2012. Comparisons with historical records show that temperatures at the base of the mixed layer are increasing at the rate of about 0.12 °C per decade, similar to those in other East African Great Lakes. The temperatures in the deep waters increased as well, including the region below a major pycnocline at 250 m. Estimates of heat transport rates suggest that this deep warming is only partly due to the warming at lake surface and sub-surface heat sources are important. Combined with vertical shifts in the depths of major pycnoclines and the observed temperature fluctuations in the deep waters, the evidence suggests that the stratification in Lake Kivu cannot be considered at steady state, with implications for the dynamics of the dissolved methane pool, which is currently being extracted for electricity generation, and interpretations of Lake Kivu history, including past mixing events. *Keywords: Africa, Lake Kivu, Global warming.*

<u>KATZER, M.C.</u>[1], SHELLEY, K.[2], and CLEMENT, G.O.[2], [1]1107 Highland Drive, Goshen, IN, 46528; [2]P.J. Palombi Middle School, 133 McKinley Avenue, Lake Villa, IL, 60046. **Bringing the excitement of real-world Great Lakes research back to the classroom--Inspiring a new generation.**

Science teachers who have collaborated with Great Lakes scientists in Sea Grant, the Center for Great Lakes Literacy, and COSEE Great Lakes workshops will share learning experiences and implementation of Great Lakes content into classroom instruction. Both teachers gained extensive content knowledge and an appreciation for pressing issues facing the Great Lakes ecosystem and human impacts. The presenters will describe scientific skills gained through involvement in land- and shipboard-based educator/scientist workshops, including the curriculum resources being used to teach their students on a multitude of issues, such as aquatic invasive species and climate change. The middle school teacher will share his teaching approach;

i.e., student research projects on aquatic invasive species following a lab on classifying local invertebrate aquatic species. The high school teacher will offer examples of student stewardship projects that helped boaters in the Fox Chain of Lakes learn about effective AIS control measures. This session will underscore the importance of increasing students' Great Lakes literacy to not only pique their interest in this system, but to also help them better understand the extent of human impact on the Great Lakes; thereby helping people make important decisions to protect and sustain this unique watershed. *Keywords: Environmental education, Watersheds, Invasive species, Zebra mussels, Public education.*

KEELER, K.M.[1], BUNNELL, D.B.[2], WARNER, D.M.[2], DAVIS, B.M.[2], CHRISCINSKE, M.A.[2], LONDER, J.G.[2], OGILVIE, L.O.[2], and O'MALLEY, B.P.[2], [1]University of Michigan School of Natural Resources and Environment, 440 Church St., Ann Arbor, MI, 48109; [2]USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105. **Can invasive spiny water flea (*Bythotrephes longimanus*) be controlled through fish consumption in Lake Michigan?**

The invasion of the spiny water flea (*Bythotrephes longimanus*) has had multiple impacts on Great Lakes foodwebs. For fish, this invader has reduced the densities of more easily captured prey, such as cyclopoids and cladocerans. *Bythotrephes* is also a readily available, yet low energy, prey item for juvenile and adult fishes in summer and fall. Therefore any ability to effectively control *Bythotrephes* production through consumption by fishes would have dual impacts on fish and zooplankton communities. We compared estimates of zooplankton production to fish consumption from April, July, and September 2010 in the northern basin of Lake Michigan offshore from Sturgeon Bay, WI and Frankfort, MI. Overall production of *Bythotrephes* was highest in September and at Sturgeon Bay. Preliminary results from gut analysis and bioenergetics modeling indicate that juvenile and adult alewife (*Alosa psuedoharengus*), rainbow smelt (*Osmerus mordax*), and bloater (*Coregonus hoyi*), and benthivores slimy sculpin (*Cottus cognatus*), deepwater sculpin (*Myoxocephalus thompsonii*), and round goby (*Neogobius melanostomus*) each contributed to the overall consumption of *Bythotrephes*. *Keywords: Bioenergetics, Bythotrephes longimanus, Invasive species, Zooplankton, Lake Michigan, Fish diets.*

KELLER, R.P.[1], HOWETH, J.G.[2], GANTZ, C.A.[3], MANDRAK, N.E.[4], and LODGE, D.M.[3], [1]Department of Environmental Science, Loyola University Chicago, Chicago, IL, 60660; [2]Department of Biological Sciences, University of Alabama, Tuscaloosa, AL, 35487; [3]Department of Biological Sciences, University of Notre Dame, Notre Dame, IN, 46556; [4]Center for Excellence in Aquatic Risk Assessment, Fisheries and Oceans Canada, Burlington, ON, L7R 486. **Risk Assessment for Fishes in the Laurentian Great Lakes.**

Many non-native fish species enter the Laurentian Great Lakes Basin through the aquarium, watergarden, live food, live bait, biological supplies, and aquaculture trades. Determining which species pose a high risk of becoming invasive is a high priority so that appropriate steps can be taken to minimize invasions. We have gathered a list of all known fishes introduced to the Great Lakes. For each species we determined current established status, and conducted a survey of experts to estimate species impact levels. Data covering 18 traits of each species were collected and used to develop CART decision trees for the invasion steps from introduced to established, and from established to harmful. The most important trait for explaining success is climate match between native ranges and the Great Lakes. Important traits at the harmful stage are trophic guild and fecundity. To make the determination of establishment risk faster we have assessed the climatic match between all fish families and the Great Lakes. This allows rapid removal of many species from the pool that would otherwise need assessment. In combination, these tools allow for rapid assessment of the invasion risk posed by new fish species, and offer managers the opportunity regulate trade in species likely to cause harm. *Keywords: Invasive species, Risk assessment, Fish.*

KELLY, B.[1] and KEELER, B.[2], [1]University of Waterloo, Waterloo, ON; [2]University of Minnesota, Minneapolis, MN. **Energy in the Great Lakes St-Lawrence Basin: Past Trends, Current Impacts and Future Scenarios.**

Energy demand in the Great Lakes St. Lawrence Basin (GLB) over the past 50 years has been met by a mix of sources, mainly coal, oil, conventional natural gas, nuclear, and hydropower. Over the last decade, however, a shift towards increased capacity in renewable energy production and increased reserves of unconventional natural gas has occurred. As each energy source has a unique set of social and environmental impacts the future sustainability in the GLB will be intimately tied to trends in energy production and consumption. This paper synthesizes the past 50 year trends in energy use in the GLB and identifies the impacts of these energy sources on environmental and social drivers. Based on the historical and current energy trends, this paper explores three alternate scenarios for energy dynamics within the GLB, 50 years into the future. The three scenarios developed are: Low Carbon, Business as usual, and High Carbon. These scenarios outline the importance of understanding the interactions between energy dynamics, sources, and the additional drivers of change within the GLB into the future, while also trying to reconcile the needs of Great Lakes Basin inhabitants. *Keywords: Carbon, Carbon, Climate change, Climate change, Great Lakes basin, Great lakes basin.*

KELLY, J.J.[1], BINH, C.T.T.[1], TONG, T.[2], GAILLARD, J.F.[2], and GRAY, K.[2], [1]Loyola University Chicago, Chicago, IL; [2]Northwestern University, Evanston, IL. **Assessing Effects of a Widely-Used Nanomaterial, Nano-Titanium Dioxide, on Freshwater Microbial Communities.**

Nano-TiO2 is one of the most widely used engineered nanomaterials, with diverse applications ranging from sunscreens, pigments, and construction materials to solar cells and photocatalysts. When illuminated nano-TiO2 can generate reactive oxygen species, which can be toxic to a variety of organisms. Production of nano-TiO2 has increased rapidly over the last decade and this trend is projected to continue, leading to potential risks associated with the unintended release of this material into the environment. One possible fate of nano-TiO2 is entry into freshwater ecosystems; yet relatively little is known about its effects on microorganisms within these habitats. We are using two complementary approaches to assess the potential effects of nano-TiO_2 on stream and lake ecosystems: high-throughput screening (HTS) and model stream experiments. Our HTS work has revealed that the toxicity of nano-TiO_2 depends on the type and morphology of the nano-TiO_2 as well as on the properties of the aqueous matrix (e.g. stream water vs. lake water), and that different bacterial species display varied sensitivities to nano-TiO_2. Model stream experiments have shown that nano-TiO_2 can have negative impacts on the abundance and diversity of benthic bacteria. These results demonstrate some of the concerns associated with engineered nanomaterials. *Keywords: Benthic flora, Nanomaterials, Microbiological studies, Environmental effects.*

KELLY, J.R., YURISTA, P.M., and MORRICE, J.A., US EPA Mid-Continent Ecology Division, 6201 Congdon Boulevard, Duluth, MN, 55804. **Attenuation of Landscape Signals through the Coastal Zone: A Basin-wide Analysis for the US Great Lakes Shoreline, Circa 2002-2010.**

We compare statistical models developed to describe a) the relationship between watershed properties and Great Lakes coastal wetlands with b) the relationship developed between watershed properties and the Great Lakes nearshore. Using landscape metrics from the GLEI project (Danz et al. 2007; Niemi et al. 2007) and sites (in the case of wetlands as well as the nearshore) or continuous in situ tow tracks (only in the case of the nearshore) to represent the entire US shore, we contrasted the geographic and spatial patterns of model predictions of chloride and specific conductivity in wetlands and the nearshore. Differences in concentrations and spatial patterns in the models are used to infer the level of dilution of conservative ions and further, changes in non-conservative nutrients with flows through the coastal zone. *Keywords: Coastal ecosystems, Watersheds, Water quality.*

KELLY, J.R., TREBITZ, A.S., HOFFMAN, J.C., and PETERSON, G.S., US EPA Mid-Continent Ecology Division, 6201 Congdon Boulevard, Duluth, MN, 55804. **Early Detection Network Design and Search Strategy Issues.**

We conducted a series of field and related modeling studies (2005-2012) to evaluate search strategies for Great Lakes coastal ecosystems that are at risk of invasion by non-native aquatic species. In developing a network, we should design to achieve an acceptable limit of detection (non-detection is a significant issue), as well as maximize search efficiency to detect invasive species while they are still uncommon. We have used our empirical studies to assess some factors which may improve the efficiency of a search for detection of "new," rare, but potentially invasive species. We also have sampled extensively across the entire nearshore of the Great Lakes, and thus have examined sampling efforts spread at different spatial scales--from the intensive case study efforts in individual embayments, to a set of embayments within a somewhat localized region, to the coastal waters along an entire Great Lake's coastline. Our case studies at extensive and intensive scales are used to identify issues (technical as well as program objectives) to consider in developing a Great Lakes-wide network. *Keywords: Biological* *invasions, Design objectives, Coastal ecosystems, Search strategies, Monitoring, Efficiency of detection.*

KENDALL, A.D., LUSCZ, E.C., MARTIN, S.L., and HYNDMAN, D., 206 Natural Sciences Building, Michigan State University, East Lansing, MI, 48824. **From Landscape Application to the River Mouth: A Fully Explicit Simulation of Nutrient Loads Across Lower Michigan, USA.**

Nutrient exports from the landscape to streams, lakes, wetlands, and the Great Lakes are of critical concern to a wide swath of researchers, policy makers, and the general public. Nutrient issues can have local impacts, yet be regional in scope--usually requiring simulation models to predict outcomes of mitigation efforts. However, fine-resolution regional-scale simulations are outside the capabilities of most traditional approaches. Here we present a hybrid process-statistical model to predict hydrologic fluxes across the landscape at hourly scales, and the concentrations of nutrients carried by those waters. All major sources of nutrients are described at 30-meter resolution, which are then routed through surface and subsurface pathways via process-based hydrologic model, the Integrated Landscape Hydrology Model (ILHM), with uptake and loss of nutrients described by a spatially-explicit statistical model. A simulation encompassing all of the watersheds draining the Lower Peninsula of Michigan shows considerable predictive capability across the full range of nutrient loading conditions. Preliminary simulations of altered loading under climate change scenarios illustrate some of the potential uses for this new predictive simulation capability. *Keywords: Nutrients, Streams, Model studies.*

KENNEDY, G.W., BENNION, D., MANNY, B.A., and ROSEMAN, E.F., US Geological Survey - Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105. **Ground Truth and Site Assessment of Model Predicted Fish Spawning Habitat Areas in the St. Clair-Detroit River System.**

Large scale predictive modeling of potential fish spawning areas in the St. Clair-Detroit River System (SCDRS) for a select guild of lithophilic spawning fishes was completed in 2011. Based on model predictions, up to 11 priority areas were identified as potential spawning sites in the SCDRS. Site assessment commenced in 2012 using side-scan sonar and underwater video to map and classify river bottom substrates, ground truth model outputs, and further asses the physical properties and biologic activity. Analysis of ground truth data indicate over 700 'targets' of interest scattered throughout the sites, ranging in size from a few, to tens, of sq. meters. These targets were primarily debris fields, but also consisted of natural rock piles. It appears that these relatively small patches of debris and rock substrate contribute greatly to fish habitat, providing structure, potential food sources, and relief from the current. Assessments will continue in 2013 at additional SCDRS sites to continue validation of model results, quantify physical properties, and assess use by spawning fish. These data will help to identify and select suitable sites for construction of fish spawning reefs via the addition of suitable rock - rubble spawning substrates. *Keywords: Habitats, Remote sensing, Spatial analysis.*

KENOW, K.P.[1], FOX, T.J.[1], HOUDEK, S.C.[1], LUBINSKI, B.[2], HEARD, D.[3], MEYER, M.W.[4], and FARA, L.[1], [1]U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, WI, 54603; [2]U.S. Fish and Wildlife Service, Regional Office, Region 3, Bloomington, MN, 55437; [3]University of Florida, College of Veterinary Medicine, Gainesville, FL, 32610; [4]Wisconsin Department of Natural Resources, Science Services, Rhinelander, WI, 54501.
Distribution and Foraging Patterns of Waterbirds on Lake Michigan with Implications for Exposure to Botulinum Toxin.

Waterbird die-offs resulting from type E botulism were first documented in Lake Michigan during the early 1960s. In recent years, occurrences of botulism-related mortality have been reported throughout several of the Great Lakes and outbreaks have increased in frequency. The actual sites of toxin exposure among birds remain unclear and the physical and ecological factors that lead to botulism outbreaks are poorly understood. Central to this question are feeding patterns and exposure routes of sentinel waterbird species, such as common loons (*Gavia immer*), historically at risk to botulism die-offs. During the autumns of 2010-2012, we examined the distribution of waterbirds using Lake Michigan through aerial surveys, and documented the migration movements and foraging patterns of common loons equipped with archival geo-locator tags and satellite transmitters. Radiomarked loons frequented areas up to 35 km offshore in up to 60 m water depth. Evidence suggests common loons forage on bottom-dwelling fish in Lake Michigan at depths up to 45 m. Waterbird distribution data are being used to derive species-specific habitat associations and to inform a hydrodynamic carcass source tracking model. The results of this work are expected to elucidate where waterbirds are likely to be exposed to forage harboring type E botulinum toxin. *Keywords: Avian ecology, Type E botulism, Lake Michigan, Waterbird distribution, Foraging patterns.*

KERFOOT, W.C.[1], YOUSEF, F.[1], HOBMEIER, M.M.[1], HIRSCH, J.K.[2], and MAKI, R.P.[3], [1]Department of Biological Sciences and Lake Superior Ecosystem Research Center, Michigan Technological University, Houghton, MI, 49931; [2]Minnesota Department of Natural Resources, St. Paul, MN, 55155; [3]Voyageurs National Park, 415 S Pokegama Avenue, Grand Rapids, MN, 55744. **Spiny Waterflea (*Bythotrephes longimanus*) Dispersal And Food Web Impacts.**

The spiny waterflea is an invasive, predaceous zooplankter that is spreading out from Great Lakes coastal waters across a temperature-defined latitudinal band that stretches from Ontario to Minnesota. Once established, Bythotrephes creates progressive impacts on zooplankton assemblages and resident fish. Extensive spatial and temporal sampling in Voyageurs National Park (VOYA) shows that accumulative effects come from both direct and indirect pathways. Smaller-bodied zooplankton, especially cladocerans, are susceptible to size-selective predation by Bythotrephes in the summer, when spiny waterflea activity is at its maximum. Zooplankton community composition, overall species diversity, and biomass are all significantly decreased. Prolonged contact with smaller-bodied prey eventually leads to failure of diapause egg recruitment in spring, and total seasonal collapse. Predatory cyclopoid or calanoid species also subsequently indirectly suffer from depleted small-bodied prey species (food resources). Effects include substantial (40-60%) loss of standing zooplankton biomass at the base of the aquatic food web. Quagga-related reduction of planktivorous fish in Lake Michigan and

subsequent release of Bythotrephes also helps to explain previously difficult to interpret changes in zooplankton species. *Keywords: Bythotrephes cederstroemii, Invasive species, Zooplankton.*

KING, A.T.[1], COWEN, E.A.[1], and RUEDA, F.J.[2], [1]DeFrees Hydraulics Laboratory, School of Civil & Environmental Engineering, Cornell University, 220 Hollister Hall, Ithaca, NY, 14853; [2]Instituto del Agua y Dpto. Ingeniería Civil, Universidad de Granada, C/Ramón y Cajal, Granada, 4 - 18071, Spain. **Incorporating Point Sources into a 3D Hydrodynamic Model to Examine Plume Fate and Residence Time Scales on the Shallow Shelf of a Large Lake.**

Cayuga Lake, located in central New York, is long (65km), narrow (3km), and deep (130m). A shallow shelf (less than 6m deep) extends 2km north from the southern end of the lake. Concern about phosphorous and sediment loading has initiated an effort to understand the physical processes that control water residence time and the fate of point sources on the southern shelf. Sources include two major tributaries, two waste water treatment plants, and a deep lake cooling facility. The fates and residence times of the various point source loads are set by the complex interaction of surface (barotropic) and internal (baroclinic) wave forcing, inflows from the point sources themselves, meteorological conditions, the earth's rotation, and bathymetry. To unravel the processes controlling hydrodynamics on the southern shelf, we have incorporated a suite of near-field point source models based on CORMIX into the 3D hydrodynamic model Si3D. The model is verified against thermistor chain data as well as a unique concentration monitoring data set from herbicide treatments applied near the mouth of the major tributaries. We use this new model to examine the relative effects of wind-forced wave activity (in particular the baroclinic), and loading from the various sources on water residence time across the shelf. *Keywords: Hydrodynamic model, Hydrodynamics, Pollution load.*

KINZELMAN, J.L.[1] and MCLELLAN, S.L.[2], [1]Racine Health Department Laboratory, 730 Washington Avenue, Racine, WI, 53403; [2]UW-Milwaukee, School of Freshwater Sciences, 600 E. Greenfield Avenue, Milwaukee, WI, 53204. **The Use of DNA-based Methods as Part of a Multi-parameter Water Quality Assessment Program.**

Water quality monitoring has traditionally employed culture-based methods to estimate fecal indicator bacteria (FIB), a measure of human health risk. Recent epidemiologic studies have reaffirmed their utility but there exists a desire, especially at beaches, to provide water quality results in real time. This has driven the development of quantitative, real-time polymerase chain reaction (qPCR) methods for the enumeration of FIB. Microbial source tracking (MST) has also utilized molecular methods; e.g. secondary indicators such as the human-specific Bacteroides marker (HuBac) have been employed in determining the origin of pollution. In Racine, WI both FIB and HuBac markers are quantified using DNA-based methods; North Beach being the first recreational site nationally to regulate using qPCR as the primary assessment method. Regulatory action agreement was achieved >85% of the time when FIB were quantified and reported as calibrator cell equivalents (CCE) per 100 ml compared to culture-based assays across multiple seasons. Adding HuBac to MST efforts aided in the identification

of illicit discharges and/or compromised stormwater infrastructure, targeting mitigation activities. The integration of microbial and molecular test methods have improved resource management leading to enhanced utility and direct economic benefits. *Keywords: Water quality, Monitoring, Management.*

KINZELMAN, J.L.[1], KLEINHEINZ, G.T.[2], and MEDNICK, A.C.[3], [1]Racine Health Department, 730 Washington Avenue, Room 8, Racine, WI, 53403; [2]University of Wisconsin - Oshkosh, 800 Algoma Boulevard, Oshkosh, WI, 54901; [3]Wisconsin Department of Natural Resources, 101 S. Webster Street, Madison, WI, 53707. **Improving Beach Health through the Integration of Sanitary Surveys, Rapid Methods, and Mitigation: Coast-wide Efforts in Wisconsin.**

Over the past decade, Wisconsin has made significant strides in improving recreational water quality and reducing health risks at its 119 monitored Great Lakes beaches. Successful efforts have been characterized by sound science, practical application, technological innovation, and broad-based partnership. In this presentation we will describe statewide efforts to develop and implement standardized sanitary surveys, beach mitigation projects, and rapid methods (including operational qPCR and predictive models). Integrating efforts across these three areas has proven beneficial from both a scientific and a practical standpoint. We will highlight notable examples of projects that have improved microbial water quality and reduced monitoring errors. Since data collection is central to all of these actives, we will discuss the implications of likely reductions in beach monitoring, as well as possible innovations to ensure that recent improvements in beach health are sustainable in the long-run. *Keywords: Water quality, Beaches, Monitoring, Predictive modeling, Human health, Sanitary survey.*

KLINKHAMER, C., MAHAPATRA, C.T., and SEPULVEDA, M.S., 264 Marstellar St, West Lafayette, IN, 47906. **Toxicity of the Pharmaceuticals Cotinine and Triclocarban on Green Algae and Diatoms.**

Pharmaceuticals and personal care products (PPCPs) are a new class of emerging contaminants. A single study has been conducted quantifying environmental concentrations of PCPPs in Lake Michigan (Bernot and Lauer 2011).Several PCPPs emerge as potential concern to aquatic organisms (hazard quotients > 1.0). Limited toxicological data exist for some of these PPCPs. We chose to conduct a set of studies that aim to:(1)test acute and chronic effects of cotinine and triclocarban on aquatic organisms;(2)evaluate the sensitivity of diatoms to PPCPs; and (3)conduct a mixture study exposing low trophic levels to a mixture of PPCPs similar to that reported from Lake Michigan. We present data on the effects of triclocarban and cotinine on growth of green algae (Pseudokirchneriella capricornutum) and diatoms (Cyclotella meneghiniana).We tested effects using maximum concentrations found in Lake Michigan (0.006 µg/L for cotinine and 0.01 µg/L for triclocarban).After 7 days,triclocarban caused a 60 % growth inhibition in algae EC50,(CI 0.004-0.011)= 0.007 µg/L, no effects were observed in diatoms. Cotinine reduced growth of both algae EC50,(CI 6.55-13.54)= 10.05 µg/L and diatoms EC50,(CI 0.003-0.007)= 0.005 µg/L. These results suggest that these PPCPs could be impacting the lower food chain in Lake Michigan. *Keywords: Diatoms, Emerging Pollutants, Toxic substances.*

KLUMP, J.V.[1], WAPLES, J.T.[1], BRAVO, H.R.[1], ANDERSON, P.D.[1], GRUNERT, B.[1], LABUHN, S.L.[1], FERMANICH, K.J.[2], BAUMGART, P.[2], ZORN, M.E.[2], VALENTA, T.[3], and KENNEDY, J.[3], [1]School of Freshwater Sciences, University of Wisconsin-Milwaukee, Milwaukee, WI, 53204; [2]University of Wisconsin-Green Bay, Green Bay, WI, 54311; [3]Green Bay Metropolitan Sewerage District, Green Bay, WI. **The Dynamics of Hypoxia in Green Bay, Lake Michigan.**

The southern end of Green Bay, Lake Michigan has experienced hypereutrophic conditions for decades. Accelerated nutrient loading from the watershed has resulted in excessive algal blooms, the accumulation of organic rich sediments, and recurring summertime hypoxia - conditions which have led, in part, to its designation as an Area of Concern. The dynamics and persistence of hypoxia vary from year to year, largely as the result of variations in the wind driven circulation and mixing in the bay. This paper will attempt to integrate nutrient loading, organic carbon deposition and resuspension, particle residence times, sediment oxygen demand, and hydrodynamics in order to examine these inter-annual and seasonal variations in the development of hypoxia. Data from continuous monitoring stations, sediment oxygen demand measurements, tracer studies of particle movement and deposition, and nutrient loading estimates will be examined. Projected changes in climate, with both warmer and wetter conditions, shifts in regional climatology, and an increased frequency of heavy precipitation events have the potential to alter these dynamics and the onset and strength of hypoxia.
Keywords: Biogeochemistry, Hypoxia, Green Bay, Nutrients.

KLYMUS, K.[1], CHAPMAN, D.C.[2], RICHTER, C.[2], and PAUKERT, C.[1], [1]Missouri Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife Sciences, Columbia, MO, 65211; [2]USGS, Columbia Environmental Research Center, Columbia, MO, 65211. **DNA shedding rates of Asian carps, for use in understanding field collections of eDNA.**

The use of environmental DNA (eDNA) as a tool for species detection has come to the forefront in the fight against aquatic invasive species. The technique works by extracting DNA shed into an organism's environment and using polymerase chain reaction (PCR) to identify species specific DNA. Because the tool only requires the presence of a DNA molecule, the sensitivity of the technique is higher than that of more traditional methods of species detection. Currently, eDNA is being used to detect Asian Carp, (Silver carp, *Hypophthalmichthys molitrix*, and Bighead carp, *H. nobilis*) in the Chicago Area Waterways (CAWS). Positive eDNA samples have been found in the CAWS, but intense fishing in these areas has only found one Bighead and no Silver carp. This raises the question of what eDNA can really tell us about the presence of an organism. We aim to better understand the information that this tool can provide managers. In a controlled laboratory setting, we first investigated how much DNA a single fish sheds into the environment and the variability of these eDNA measurements using quantitative PCR. Then using a series of manipulative lab experiments, we studied how temperature, biomass, and diet affect the shedding rate of eDNA. Future field studies will later assess the applicability of these data. *Keywords: Carp.*

KOCH, K.[1], SLAWECKI, T.A.D.[1], PAIGE, K.[2], LEGER, W.[3], and GRANNEMAN, N.G.[4], [1]LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108; [2]GLOS, 229 Nickels Arcade, Ann Arbor, MI, 48104; [3]Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [4]U.S. Geological Survey, 6520 Mercantile Way, Suite 5, Lansing, MI, 48911. **Metadata Publication: A Best Practice for Data Management.**

An important barrier to effective sharing of research and monitoring data in the Great Lakes is the difficulty of discovery. Many agencies and research programs hold extensive collections of potentially useful data whose existence is not widely appreciated. One approach to increasing the discoverability (and transparency) of datasets is to develop and publish descriptive metadata that document the who, what, when, where, why, and how of data collection for each study. Publication of standards-compliant metadata through portals like the Global Earth Observation System of Systems (GEOSS) provides stakeholders everywhere with the opportunity to find datasets and evaluate their utility. The Great Lakes Observing System, one of the partners in the GEOSS Great Lakes Testbed, will be used to demonstrate how discoverability, transparency, and interoperability improve access to hydrologic and environmental data in the Great Lakes. Ready access to these data supports implementation of policy efforts like the Great Lakes Compact, the Great Lakes Water Quality Agreement, and the National Ocean Policy. *Keywords: Data storage and retrieval, Metadata, Observing systems.*

KOCOVSKY, P.M.[1] and MANDRAK, N.E.[2], [1]US. Geological Survey, Lake Erie Biological Station, Sandusky, OH, 44870; [2]Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, Burlington, ON, L7R 4A6. **Recovery of Silver Chub *Macrhybopsis storeriana* in Lake Erie.**

Silver Chub *Macrhybopsis storeriana* in the Great Lakes-Upper St. Lawrence is a species of special concern in Canada with a recovery potential assessment underway. The species is not considered endangered or threatened in the United States. Here we review the current state of knowledge of the silver chub population in western Lake Erie, including the 50-year population trend in nearshore Ohio waters and a recent diet analysis, and present Ontario's preliminary recovery plan. *Keywords: Fish, Lake Erie.*

KOCOVSKY, P.M.[1], ZHAO, Y.[2], WIRICK, R.E.[1], and KERETZ, K.R.[1], [1]6100 Columbus Ave, Sandusky, OH, 44870; [2]320 Milo Rd R.R.#2, Wheatley, ON. **Effect of Stock Size, Climate, Predation, and Trophic Status on Recruitment of Gizzard Shad in Lake Erie.**

Gizzard shad (Dorosoma cepedianum) are a primary food resource for walleye (Sander vitreus) which have a significant commercial and recreational value in both the United States and Canada. In recent years, the ability to accurately analyze gizzard shad populations has declined as sampling efforts of near shore waters, where gizzard shad are most abundant, have decreased. We used Partnership autumn gillnet data for adult gizzard shad collected by the Ontario Ministries of Natural Resources (OMNR) and Ohio Division of Wildlife(ODNR). Autumn bottom trawl data, collected by OMNR, ODNR, and U.S. Geological Survey (USGS), of young

of year catches was used to create a stock recruitment model. Several climate variables, lake trophic status, and a walleye predation index were used as exponent modifiers, and the best model was chosen using AIC. By assessing gizzard shad recruitment, we can provide important data to managers tasked with setting harvest limits as well as shedding more light on forage fish dynamics within Lake Erie. *Keywords: Gizzard Shad, Recruitment, Stock assessment.*

KOH, W.[1], MAREK, R.F.[2], THORNE, P.S.[1], DEWALL, J.[3], and HORNBUCKLE, K.C.[2], [1]Interdisciplinary Graduate Program in Human Toxicology, Iowa City, IA, 52242; [2]Department of Civil and Environmental Engineering, Iowa City, IA, 52242; [3]Department of Occupational and Environmental Health, Iowa City, IA, 52246. **Determination of Polychlorinated Biphenyls (PCBs) and hydroxylated metabolites (OH-PCBs) in human blood serum from populations in East Chicago, IN and Columbus Junction, IA.**

PCBs are persistent and bioaccumulating toxic pollutants that pose human health risks. Although commercial production of most of these compounds was reduced and then banned in the 1970s, they are still present in our environment and found in humans. In this study, we determine PCBs and their metabolites in human blood serum in two populations. Human blood serum samples are collected as part of the AESOP Study from East Chicago, an industrialized area with known high PCBs exposure which is located at the southwest corner of Lake Michigan, and Columbus Junction, a rural area with no recognized current or historical PCB contamination. Our methods enable us to evaluate all 209 PCB congeners and 65 OH-PCBs congeners. After a series of extraction and clean-up procedures, samples are analyzed using gas chromatography with tandem mass spectrometry (GC-MS/MS) for both PCBs and OH-PCBs. Our results show that PCBs and OH-PCBs are detected in human blood serum collected in 2010 from both populations living in East Chicago, IN and Columbus Junctions, IA. We also compare our results to human blood serum collected in 2008 from the same individuals. *Keywords: Lake Michigan, Bioaccumulation, PCBs.*

KOSIARA, J.M.[1], COOPER, M.J.[1], UZARSKI, D.G.[2], and LAMBERTI, G.A.[1], [1]University of Notre Dame, Department of Biological Sciences, Notre Dame, IN, 46556; [2]Institute for Great Lakes Research, Central Michigan University, Mount Pleasant, MI, 48858. **Relationships between community metabolism and fish production in Great Lakes coastal wetlands.**

Great Lakes coastal wetlands are hot spots of primary production and respiration, with rates often exceeding those in pelagic habitats. This elevated metabolism likely translates to the high fish productivity of coastal wetlands. However, a direct link between primary and tertiary productivity has not been quantified in these systems. We sampled fish and measured community metabolism in wetlands of Lake Huron and Lake Michigan in 2008 and 2011 to look for relationships between wetland metabolism rates and fish productivity. Metabolism, specifically gross primary production, was correlated with fish biomass while respiration was highly correlated with fish species richness. Based on these results, we propose that the elevated metabolism of coastal wetlands supports both fish production and diversity. To explore this relationship over a larger spatial scale, we also compared water column chlorophyll a (as a

surrogate for primary production) to fish species richness and biomass in wetlands across Lake Huron. Additional research is needed to further quantify the link between primary and tertiary productivity in Great Lakes coastal wetlands but our results suggest a direct coupling of these processes. *Keywords: Metabolism, Coastal wetlands, Fish.*

KOSLOW, M., 213 W. Liberty Street, Suite 200, Ann Arbor, MI, 48104. **Guiding Restoration in a Changing Great Lakes Climate: Steps and Tools.**

Climate-smart restoration is the process by which restoration approaches and goals integrate science of current and future climatic change. Currently multiple climate-smart restoration activities are taking place in the Great Lakes region with support from the Great Lakes Restoration Initiative (GLRI). Benefits of climate-smart restoration include enhanced value of investments and increased project durability. This presentation will discuss two climate-smart restoration projects: implementation in the Maumee Bay Area of Concern (AOC) and design in St. Mary's AOC. In Ohio, restoration partners examined tree species suitable considering climate change impacts like warming air temperatures and changes to precipitation. Methodology in this analysis combined recent historical measurements of air temperature and precipitation differences, climate model output from recent literature review and tools, combined with model outputs from the U.S. Forest Service Climate Change Tree Atlas. Results provided information for a climate-smart tree list utilized to make seedling purchase decisions. In St. Mary's, climate-smart restoration informs fish habitat. Following a similar methodology, a vulnerability assessment is underway to inform design of climate-smart rapid habitat. Tools and processes utilized in these approaches will be outlined. *Keywords: Great Lakes basin, Great Lakes Restoration Initiative (GLRI), Climate change.*

KOWALSKI, K.P.[1], BAUSTIAN, J.J.[2], EGGLESTON, M.R.[1], and GREEN, S.A.[1], [1]USGS Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105; [2]IAP Worldwide Services, 7351 Atlantic Ave, Cape Canaveral, FL, 32920. **Measuring restoration outcomes beyond ecology: the interactions between science and management.**

The Great Lakes Restoration Initiative has supported extensive habitat restoration efforts, including many focused on coastal wetlands. However, the effectiveness and broader application of restoration strategies may be unknown unless sufficient monitoring programs are in place, and results are communicated to decision makers and used to guide future projects. Ongoing wetland restoration, research, and management at the USFWS Ottawa National Wildlife Refuge in northwest Ohio provides a good example of how science and management work together to maximize outcomes. We measured ecosystem function before and after a diked wetland was hydrologically reconnected to Lake Erie and compared these results to a wetland that remained diked. We found the restored wetland was an effective sink for nutrients and sediment, provided key nursery and spawning habitat for fish, maintained a diverse vegetated habitat, and provided habitat for a plethora of avian species. Throughout the monitoring process, we routinely communicated our findings to refuge and partner agencies, which led to several other wetland reconnection projects being constructed on refuge properties. Additionally, the results from this project have been shared with regional land managers leading to at least 8 more projects being constructed or planned throughout the Great Lakes. *Keywords: Great Lakes Restoration Initiative (GLRI), Management, Wetlands.*

KRAMER, E.L.[1], RITZENTHALER, A.A.[1], PAINE, A.L.[2], and GRONEWOLD, A.D.[3], [1]Cooperative Institute for Limnology and Ecosystem Research, University of Michigan, 4840 S. State Rd, Ann Arbor, MI, 48108; [2]University of Michigan Undergraduate Research Opportunity Program (UROP), 204 Washtenaw Ave, 1190 Undergraduate Science Building, Ann Arbor, MI, 48109; [3]NOAA Great Lakes Environmental Research Laboratory, 4840 S State Rd, Ann Arbor, MI, 48108. **Spatial, temporal, and analytical variability in near-shore water quality and its implications on management decisions.**

While all beach management decisions are guided by fecal indicator bacteria (FIB) monitoring results, the collection and analysis of near-shore water quality samples is hardly uniform within or between beach monitoring programs. If the neighboring county was to implement their sampling and analysis protocols at one of your beaches would they make the same management decision you did, or would following an alternative protocol lead them to a different management conclusion? Utilizing a robust data set collected from Macomb County, Michigan during the 2012 swimming season, we explore the variability in spatial and temporal distribution of FIB as well as the analytical variability between two U.S. EPA approved FIB enumeration methods, membrane filtration and IDEXX Colilert. By understanding where variability exists, and the scale at which it acts, we can better understand the implications that sampling and analysis variation between beach monitoring programs has on management guiding results. *Keywords: Monitoring, Decision making, Human health.*

KRAMSKI, N.A.[1], MANDRAK, N.E.[2], and MCLAUGHLIN, R.L.[1], [1]Department of Integrative Biology, University of Guelph, Guelph, ON, N1G 2W1; [2]Great Lakes Laboratory for Fisheries and Aquatic Sciences, Department of Fisheries and Oceans, Burlington, ON, L7R 4A6.
Movements of Listed Grass Pickerel *Esox americanus vermiculatus* in an Agricultural Drain and the Implications for Drain Maintenance.

Scientists and managers are being pressed to find ways to conserve biodiversity in systems that have been heavily modified by human activities. We combined PIT tags and multi-state models to quantify the movements of Grass Pickerel *Esox americanus vermiculatus* in response to experimental drain maintenance (dredging) in Beaver Creek, an agricultural drain near Fort Erie, ON. Grass Pickerel is listed as a species of special concern under Canada's Species at Risk Act. Parts of Beaver Creek require maintenance to restore drainage function. Our study focused on movement because of its importance to the ecology and life history of stream fishes. Over 2000 Grass Pickerel have been PIT tagged since 2009 and their movements monitored at seven antenna arrays installed across 13 kilometres of Beaver Creek. Multi-state models suggest that daily survival of Grass Pickerel was high in all stream sections, but movement between sections varied along the stream course. Our findings will contribute to the

development of management practices that balance the needs of the agricultural community and fish habitat managers. *Keywords: Fish tagging, Spatial analysis, Habitats, Species at Risk.*

KUCZYNSKI, A.[1] and AUER, M.T.[2], [1]Department of Civil and Environmental Engineering, Michigan Technological University, 1400 Townsend Drive, Houghton, MI, 49931-1295; [2]Great Lakes Research Center, Michigan Technological University, 1400 Townsend Drive, Houghton, MI, 49931-1295. **Implications of changes in *Cladophora* biomass in the Great Lakes: a comprehensive review of published data (1979-2010).**

The filamentous green alga, *Cladophora glomerata*, first attracted significant attention in the mid-1970s, as the species grew to nuisance proportions at sites in Lakes Erie, Huron, Michigan and Ontario. Nuisance growth and attendant losses of ecosystem services (fouling of beaches, death of waterfowl and clogging water intakes) was shown result from excess phosphorus loads. Limits on phosphorus in wastewater effluent (1 mg/L) appeared to help curb proliferation of the alga. Although phosphorus limits remain in effect, nuisance levels of *Cladophora* have returned. The invasion of the Great Lakes by quagga and zebra mussels in the late 1980s and early 1990s has perturbed the ecosystem in ways that favor *Cladophora* growth. While it is well accepted that increased transparency has extended the area of lake bottom available for colonization, the effects of changes in phosphorus cycling on algal biomass density are unclear. Here, a compilation and analysis of published *Cladophora* biomass data for lakes impacted by nuisance growth demonstrates that higher algal biomass densities have been observed in the period following dreissenid invasion. These findings suggest that dreissenid-driven modifications of P cycling have had an impact on the recurrence of nuisance growth.
Keywords: Zebra mussels, Phosphorus, Cladophora.

KUEBBING, S.E., NUÑEZ, M.A., DIMARCO, R.D., and SIMBERLOFF, D., Department of Ecology & Evolutionary Biology, University of Tennessee, Knoxville, TN, 37996. **To eat or not to eat? Risks associated with harvesting invasive species for human consumption.**

A popular plan for managing invasive species is promoting their harvest for food. Managers should consider the associated risks with promoting invasives in an economic marketplace before beginning a harvest program. These risks include creating economic incentives that might lead to harvest program participants arguing to maintain a nonnative population or moving nonnative species to previously uninvaded areas. Using invasives as an economic resource may trigger a local community to protect these species, to facilitate their incorporation into the local culture, and generate severe management problems. Finally, harvests should insure that efforts would reduce an invader's population size or growth rate and not be a form of compensatory mortality. We consider the feasibility and risk of invasive harvest programs. We review qualitative differences between native populations that have been harvested to extinction versus invasive populations and analyze the use of demographic matrix models to evaluate program feasibility. There are potential benefits of harvest programs aside from control or eradication, such as heightening awareness of invasive species. However, unless a harvest program is likely to reduce an invaders population, managers should be wary of harvest

programs that could produce results opposite to those proposed. *Keywords: Risk assessment, Biological invasions, Policy making.*

KUHANECK, R.M., MAYER, C.M., and BRIDGEMAN, T.B., University of Toledo, 2801 W Bancroft St, Toledo, OH, 43606. **Vegetation on ripraped shorelines: implications for management of invertebrate communities and restoration of nearshore areas.**

Coastal areas are increasingly habited by humans because of their attractiveness for recreation, aesthetics, and industrial purposes. Artificial structures, such as riprap, are used to prevent erosion but also have been shown to reduce biodiversity. The goal of our study was to examine the relationship between riprap altered shorelines, sediment size, organic matter and invertebrate communities in areas that had added shoreline vegetation and those that had not. Using broad taxonomic groups, we found that overall invertebrate diversity was 30% greater in areas adjacent to shorelines with added vegetation. The most abundant class, Oligochaeta, showed opposite trends with abundance increasing at least 50% at non-vegetated sites. The relationship between sediment composition and shoreline type was found to be the most significant driver of invertebrate community changes, with the ratio of silt to sand being seven times greater in the absence of vegetation. In the western basin of Lake Erie, where most shorelines have riprap alterations, adding vegetation should be considered as a possible management technique. *Keywords: Lake Erie, Vegetation, Nearshore, Benthos.*

LAMBERT, R.S.[1], AUER, M.T.[2], DOWNER, B.E.[2], MATTHEWS, D.A.[3], HURTEAU, C.A.[3], and EFFLER, S.W.[3], [1]LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108; [2]Civil & Environmental Engineering Michigan Technological University, 1400 Townsend Drive, Houghton, MI, 49931; [3]Upstate Freshwater Institute, P.O. Box 506, Syracuse, NY, 13214.
Phosphorus Bioavailability of Point Sources to the Great Lakes insights from Onondaga Lake.

Recently, nuisance algal blooms have affected nearshore sections of the Laurentian Great Lakes. This led to adverse effects including beach closures and fouling of power plant intakes. These blooms are caused by several factors, including point and non-point source phosphorus (P) loads and the invasion of dreissenid mussels. Tighter P limits for wastewater plants and reductions in non-point loads could reduce the occurrence of blooms. A management strategy for loading reductions should consider the bioavailability of P from all sources. We performed algal bioassays to determine the bioavailability of particulate and dissolved P from effluent of a wastewater plant that discharges to Onondaga Lake, New York, which flows to Lake Ontario. In 2005, the plant was upgraded to include a high rate flocculated settling process (i.e. Actiflo) for P removal. The new technology reduced total P effluent concentrations by 76% (436 µg/L in 1996 & 103 µg/L in 2010) and bioavailable P by 91% (294 µg/L in 1996 & 27 µg/L in 2010). This resulted in a clear decrease in algal blooms in the lake. A similar technology could be applied to the Great Lakes for control of nearshore algal growth. This presentation will focus on the reduced P load to Onondaga Lake and how this technology could be applied to other wastewater plants on the Great Lakes. *Keywords: Phosphorus, Eutrophication, Nutrients.*

LANTRY, B.F.[1], ADAMS, J.[1], CHRISTIE, G.[2], SCHANER, T.[3], BOWLBY, J.[3], KEIR, M.[2], LANTRY, J.R.[4], SULLIVAN, P.[5], BISHOP, D.[4], TRESKA, T.[6], and MORRISON, B.[3], [1]USGS Great Lakes Science Center, Ann Arbor, MI; [2]Environment Canada, Burlington, ON; [3]Ontario Ministry of Natural Resources, Picton, ON; [4]New York State Department of Environmental Conservation, Great Lakes Unit, NY; [5]Department of Fisheries and Oceans Canada, Sault Ste. Marie, ON; [6]US Fish and Wildlife Service, New Franken, WI. **Relationships Between Sea Lamprey and Preferred and Alternate Hosts in Lake Ontario.**

Despite years of control, Sea lamprey populations in the Great Lakes continue to threaten Lake Trout restoration as well as the benefits provided by lucrative sport-fisheries. Reviews of years of research have identified key uncertainties in assessing damage caused by Sea Lampreys including wound healing rates and the effects that alternate host populations have on Sea Lamprey - Lake Trout interactions. By using long-term data series from State, Federal and Provincial agencies we examined seasonal and annual wounding rates on Lake Trout, Chinook Salmon, Coho Salmon, Brown Trout, and Rainbow Trout from lake Ontario. Simulations of monthly patterns of observed Sea Lamprey wounding on lake Trout indicated that the best fit of the observed data included healing times for A1 and A2 wounds approximating 0.5 and 2 months, respectively. Wounding rates for all trout and salmon were strongly related both to each other and to the ratio of Sea Lampreys to Lake Trout present. When Lake Trout abundance declined during 1995-2005, wounding on all other trout and salmon increased until Chinook Salmon and Brown Trout became the most intensely wounded species. Relationships demonstrated herein indicate alternate hosts can provide a surrogate to Lake Trout based indices. *Keywords: Invasive species, Fish management, Lake Ontario.*

LAPORTE, E., Michigan Sea Grant College Program, University of Michigan, 520 E. Liberty, Suite 310, Ann Arbor, MI, 48104. **Engaging the Next Generation of Stewards.**

Addressing the need for engaging Great Lakes science and math content, Michigan Sea Grant and partners developed *Great Lakes Lessons* a free, online curriculum resource for K-12 educators. *Great Lakes Lessons* includes problem-based learning tools (e.g., driving questions) about Great Lakes science, technology, engineering and math, as well as activities to explore natural resources. Curriculum content covers the food web, climate, water quality, invasive species and other topics. A primary goal is to focus on developing higher-level thinking skills by using real data and relevant topics. Recently, Michigan Sea Grant facilitated more than 12 workshops reaching 500 educators that learned to use Great Lakes data in the classroom. A new group of partners, including Michigan Sea Grant, National Geographic, the US Geological Survey and the Great Lakes Observing System are introducing *Great Lakes Fieldscope*, a new geographic information systems (GIS) tool for educators and students. Fieldscope users will upload field data and view this in relation to data from peers and professional scientists. Michigan Sea Grant and partners are connecting GIS mapping and Great Lakes curriculum to offer a suite of Great Lakes education options to increase science, technology, engineering and math proficiency. *Keywords: Environmental education, Curriculum, Great Lakes basin, Watersheds.*

LAPORTE, E., Michigan Sea Grant College Program, University of Michigan, 520 E. Liberty, Suite 310, Ann Arbor, MI, 48104. **Communicating Risks About Coastal Storms and Climate Extremes.**

How does climate impact my life? Answering this question is key to communicating about our changing climate. Michigan Sea Grant is a partner on a NSF-supported research project focused on evaluating the land, water and air factors associated with the impact of climate extremes on Great Lakes communities, industries and the ecosystem. A research team is focusing on Lake Erie, making the connection between water quality, invasive species, and climate extremes. Lake Erie, the shallowest, most productive and most southern Great Lake has been subject to many environmental challenges. Excess phosphorus from agricultural fertilizers, and detergents negatively impact the ecology of the lake. In 2011, extreme storms contributed to a severe harmful algal bloom in Lake Erie. High levels of phosphorus entering the lake, combined with invasive mussels have contributed to more frequent and severe harmful algal blooms. A communications and education team is developing and distributing information about the impact of severe storms. Education specialists are developing curriculum about climate models and working with New Tech High Schools. Outreach specialists are leveraging research results from this project to promote the use of science-based materials (e.g., articles, websites, presentations and Flickr slides). *Keywords: Climate change, Lake Erie, Environmental education, Invasive species.*

LAPORTE, E.[1], DODSON, M.A.[2], and KINNUNEN, R.E.[1], [1]Michigan Sea Grant College Program, University of Michigan, 520 E. Liberty, Suite 310, Ann Arbor, MI, 48104; [2]National Weather Service, Marquette Office, 112 Airpark Drive South, Negaunee, MI, 49866. **Public Outreach About Dangerous Currents.**

Although Michigan's Great Lakes beaches are beautiful swimming destinations many swimmers are not aware of the dangerous currents that occur along those beaches. Michigan has become the epicenter of drowning-related deaths in the Great Lakes region. According to the National Weather Service (NWS), more than 74 percent of dangerous current-related incidents in the Great Lakes occur on Lake Michigan. To address this critical public safety issue, Michigan Sea Grant is leading a public outreach project to increase knowledge about dangerous currents among state and local park staff, beachgoers, community leaders, educators and the public. Michigan Sea Grant is conducting educational workshops and developing web-based educational resources using NWS data. Michigan Sea Grant has fostered a group to evaluate existing public outreach materials and provide options to improve these materials. NOAA experts and university researchers are key partners in the effort to increase awareness about the variety of dangerous currents and emphasize the need to educate others about them. Partners include the Michigan Department of Natural Resources, the Michigan Department of Environmental Quality (MDEQ) and the NWS. Collaborators include the NOAA Coastal Storms Program, non-government organizations and local community leaders. *Keywords: Public education, Rip currents, Lake Michigan, Coastal processes.*

LARSON, J.[1], FROST, P.C.[2], XENOPOULOS, M.A.[2], WILLIAMS, C.J.[3], MORALES-WILLIAMS, A.M.[3], VALLAZZA, J.[1], NELSON, J.C.[1], and RICHARDSON, W.[1], [1]2630 Fanta Reed Road, La Crosse, WI, 54603; [2]Department of Biology, Trent University, Peterborough, ON; [3]Department of Ecology, Evolution and Organismal Biology, Iowa State University, Ames, IA. **The effect of rivermouth processing on dissolved organic matter delivery to the nearshore zone is small.**

There has been increasing interest in the effect of freshwater ecosystems on the global carbon (C) cycle. Most freshwater organic matter is dissolved (DOM) and thus understanding the role of freshwater ecosystems on global C cycles requires understanding large-scale patterns in DOM sources, movement and transformation. Here we measured the concentration of dissolved organic C (DOC) and DOM optical properties across the river to lake transition at 23 sites in the Great Lakes. Across this transition there was a shift from large quantities of mostly terrestrial DOM to small quantities of DOM of mixed origins. DOC declined from 7.9 mg C/L in rivers to 2.6 mg C/L in the nearshore. Humicity, aromaticity and terrestrial DOM components also declined across this gradient. Wetlands controlled DOC in rivers and rivermouths but nearshore zone DOC was more strongly influenced by agriculture. These differences in spatial controls over DOM possibly reflect the differences in DOM source among those ecosystems. Rivermouths as a class did not appear to strongly affect DOM concentration or composition, but rivermouth effects were higher under certain conditions. Watershed controls over nearshore DOM properties appear to be both direct (via river plumes) and indirect (via nutrient loading and microbial production). *Keywords: Estuaries, Dissolved organic matter, Watersheds.*

LAUER, T.E., Department of Biology, Ball State University, Muncie, IN, 47306. **Professional References and That Dreaded Recommendation Letter: Getting Good Ones.**

The quality of professional references and letters of recommendation can make or break the candidate's admission to graduate school or getting that job offer. The purpose of these correspondences allows the potential employer to assess the candidate on a level that is not evident from the coursework taken, the grades earned, or the type of work experienced. References and letters provide a personal perspective on the candidate's abilities and may include commentary on attributes such as independence, leadership, personality, intelligence, creativity, work ethic, interpersonal relations, ambition, attitude, and professionalism among a host of other items. The information put in this type of correspondence should be, and typically is, honest and forthright regarding the candidate's abilities. To do otherwise is fraudulent and would ultimately reflect poorly on the individual providing the reference. Soooooo, how do you get a good reference? Start early and act often in distinguishing yourself and your abilities, particularly out of the classroom. Accentuate the positive and minimize the negative. Despite our best efforts, no one is perfect, but the best recommendations are written for those that strive to be the best.
Keywords: Education.

LAURENT, K.L.[1], CREED, I.F.[1], FRIEDMAN, K.B.[2], KRANTZBERG, G.[3], and SCAVIA, D.[4], [1]Western University, Canada, London, ON, N6A 5B7; [2]State University of New York at Buffalo, Buffalo, NY, 14260-1100; [3]McMaster University, Hamilton, ON, L8S 4L8; [4]University of Michigan, Ann Arbor, MI, 48104. **Great Lakes Futures Project - How tapping into the imagination of multiple generations can lead to innovative solutions for the socio-ecological sustainability of this internationally important Basin.**

The Great Lakes Futures Project started as a grassroots movement that has evolved into a major trans-boundary, trans-disciplinary initiative focused on translating our understanding of past and future trends of the major drivers affecting the Great Lakes-St. Lawrence River Basin into recommendations for policy reforms. In this presentation, we introduce the concept of scenario analyses, and demonstrate how its application to the Great Lakes-St Lawrence River Basin can be used to generate a 100 year discourse, from 1960 to 2060, of life in the basin. We describe how we were able to engage about 100 Great Lakes students, researchers and stakeholders from 20+ Canada and US academic institutions, government, non-government and industry covering the many faceted dimensions of the drivers that influence the socio-economic-ecological sustainability of this basin. We present the major components of scenario analyses, including: selection of drivers of change, identification of the two forces that provide the basis for the future scenarios, description of the four alternative futures, and how the process of "futuring" can lead to innovative solutions to the problems facing this basin.
Keywords: Management, Scenario analysis, Great Lakes basin, Political aspects.

LAWRENCE, P.L., University of Toledo, Mail Stop 140, Toledo, OH, 43606. **Restoration and Resiliency in Great Lakes Areas of Concern: Experience with 25 years of efforts in the Tenmile Creek/Ottawa River, Maumee Area of Concern, Ohio (1987-2012).**

November 18, 2012 represented the 25th anniversary of the 1987 amended Great Lakes Water Quality Agreement, which established the 43 Great Lakes Areas of Concern and associated local Remedial Action Plans. The Agreement, signed in Toledo, Ohio, advanced the regional efforts to address water quality concerns with the Toledo area of NW Ohio, including the Tenmile Creek/Ottawa River watershed which would be a major focus of the Maumee RAP activities through federal, state, and local efforts and partnerships. The experiences with research, monitoring, data collection, studies and associated analysis, clean-up, remediation, public outreach and education, community engagement, and habitat improvements within the Tenmile Creek/Ottawa River watershed are indicative of the challenges, barriers, opportunities, and successes founds throughout the Great Lakes AOCs. The last twenty five years of progress in the watershed can be described in four stages: characterization, community actions, environmental remediation, and restoration. Major efforts include assessment of sediment contaminates, engagement of local partners and citizens to create a dialogue on issues and concerns, the $49 million Great Lakes Legacy Act funded sediment removal and advancement of riparian and wetland habitats with several major projects. *Keywords: Water quality, Ohio, Urban watersheds, RAPs, AOC, Environmental policy.*

LEADLEY, T.A.[1], JOHNSON, T.B.[2], and DROUILLARD, K.G.[1], [1]Great Lakes Institute for Environmental Research, University of Windsor, 401 Sunset Ave, ON, N9B3P4; [2]Glenora Fisheries Station, Ontario Ministry of Natural Resources, Picton, ON, K0K 2T0. **The bioenergetic costs of contaminant stress in Detroit River Brown Bullheads.**

Bioenergetic metrics in fish such as temperature dependent standard metabolic rates (SMR) are often modelled as species specific attributes. Few studies have considered how SMR may change in populations of the same species and water body exposed to different types of stress. This study examined SMRs in two populations of Brown Bullhead (Ameiurus nebulosus) collected from the Detroit River. One population was collected from the highly contaminated Trenton Channel and the second population from Peche Island, an upstream reference area of low contamination. Past studies on genetics and chemical signatures demonstrate limited connectivity between the two populations. In 2010 post reproductive bullheads were collected from Peche Island (PI) N=17) and (Trenton Channel (TC) N=23). Acute SMRs were measured by intermittent respirometry. Respirometry results indicate that the mean SMR (mgO2/kg/hr)@23℃ of bullheads from TC (N=23: 100.9 mgO2/kg/hr) were significantly higher than mean SMR observed form PI (N=17: 84.7 mgO2/kg/hr) ($p < 0.05$). The study demonstrates differences in metabolic performance of two populations. Additional work is being carried out to measure SMR in acclimated and F1 fish to determine if SMR differences between the population reflect heritable or acclimation responses. *Keywords: Bioenergetics, Fish.*

LEBLANC, J.P. and CHOW-FRASER, P., McMaster University, 1280 Main St. W., Hamilton, On, L8S 4K1. **Potential Muskellunge Population Declines in Southeastern Georgian Bay Resulting from Multiple Coastal Wetland Stressors.**

The musky (*Esox masquinongy*) fishery of Georgian Bay, Lake Huron, is a world class trophy fishery that is economically and ecologically important for Ontario. One of the main goals of the management program is to maintain a naturally reproducing population of large individuals through highly restrictive harvest regulations to support its trophy status. Unfortunately, this management program offers no protection to critically important breeding habitat. Over the past 30 years, significant increases in shoreline modification in southeastern Georgian Bay, as well as sustained low water levels since 1999, have homogenized the aquatic flora and fauna, reducing habitat structure. We will show that historic muskellunge nursery habitats have become unsuitable to support young-of-year (YOY), and this has likely led to declines in the Severn Sound sub-population. The unique geomorphology of this region has made it difficult to apply habitat requirements observed elsewhere to manage populations in Georgian Bay. This research will help elucidate habitat requirements for juvenile muskies in Georgian Bay and will be used to develop a Habitat Suitability Index that can be used to identify and protect critically important musky breeding habitat. *Keywords: Coastal wetlands, Nursery habitat, Georgian Bay, Muskellunge, Water level, Population declines.*

LEE, J.[1], TSENG, S.[1], ZHANG, F.[1], LEE, C.[1], MARION, J.[1], LIANG, S.[2], and SHUM, C.K.[1], [1]Ohio State University, 1841 Neil Avenue, Columbus, OH, 43210; [2]University of Florida, Gainesville, FL. **Integrated Approach for Quantifying Cyanotoxins at Lake Erie Beaches using Molecular Tools and Satellite Remote Sensing.**

The Great Lakes are the largest source of fresh surface water in North America, serving 30 million citizens of the U.S. and Canada and holding 84% of North America's supply of surface fresh water. Harmful cyanobacteria are significant management and public health concerns as the bloom frequency increases in Lake Erie. Remotely sensed satellite-based measurements of water color were conducted with Medium Resolution Imaging Spectrometer (MERIS) and calibrated with in situ measurements of cyanobacteria pigment, microcystin, Microcystis aeruginosa, and microcystin producers by flurorometer, quantitative polymerase chain reaction, and ELISA. Spaceborne spectral images provided assessment of Lake Erie cyanobacterial blooms with microcystin detected in 33.8% of the samples with concentrations up to 0.50 µg/L. Microcystin concentrations were correlated with water temperature, E.coli number, total phosphorus, and water level, but in none of the samples did microcystin levels exceed recommended drinking water standards. Our data further suggest that phycocyanin may be a superior proxy for HABs. These integrated satellite and in situ observations are critical elements needed towards building a predictive model for an eventual operational harmful algal bloom early warning system in the Great Lakes. *Keywords: Harmful algal blooms, Microcystin, Lake Erie, QPCR, Remote sensing.*

LEE, Z.[1], PAHLEVAN, N.[1], AHN, Y.[2], GREB, S.[3], and O'DONNELL, D.[4], [1]University of Massachusetts Boston, 100 Morrissey Blvd, Boston, MA, 02125; [2] Korea Ocean Research & Development Institute, P.O. Box 29, 425-600,, Ansan, Korea; [3] Wisconsin Department of Natural Resources, 101 South Webster Street, Madison, WI, 53703; [4]Upstate Freshwater Institute, P.O. Box 506, Syracuse, NY, 13214. **A robust approach to directly measure water-leaving radiance in the field.**

It has been a longstanding and elusive goal to precisely measure water-leaving radiance (Lw; or its equivalent property, remote-sensing reflectance) in the field. This is because the conventional approaches do not provide a direct measurement of Lw, but rather various related components are measured and subsequently used to derive this core property. Due to many uncontrollable factors in the measurement procedure, the resulted Lw is inherently associated with various levels of uncertainties. Here we present a methodology called skylight-blocked approach (SBA) to measure Lw directly in the field, along with results obtained recently in the Laurentian Great Lakes. These results indicate that Lw measured via SBA can be within an uncertainty of 5% for a wide range of waters and measurement conditions. More importantly, there is no limitation of environmental conditions for the deployment of SBA, thus high-quality data for wide range of aquatic environments can be acquired. *Keywords: Remote sensing, Data acquisition, Water quality.*

LEET, J.K.[1], SASSMAN, S.[2], AMBERG, J.J.[3], OLMSTEAD, A.W.[4], LEE, L.S.[2], ANKLEY, G.T.[5], and SEPULVEDA, M.S.[1], [1]Purdue University, Department of Forestry and Natural Resources, 195 Marsteller Street, West Lafayette, IN, 47907; [2]Purdue University, Department of Agronomy, 915 W. State Street, West Lafayette, IN, 47907; [3]USGS, Upper Midwest Environmental Sciences Center, 2630 Fanta Reed Road, La Crosse, WI, 54603; [4]Bayer CropScience, Environmental Toxicology and Risk Assessment, 2 T.W. Alexander Dr., Research Triangle Park, NC, 27709; [5]USEPA, National Health and Environmental Effects Research Lab, 6201 Congdon Blvd., Duluth, MN, 55804. **Environmental Hormones and Their Impacts on Sex Differentiation in Fathead Minnows.**

Natural and synthetic hormones have been detected in aquatic environments, leading to concern about how they may impact fish and other organisms. There is a lack of research that has been done on the impacts of hormones, particularly in mixture, on early life stage fish. The objective of this study was to evaluate sex-specific responses of fathead minnows exposed to exogenous hormones, individually and in mixture, during sexual development. We found that female fathead minnows appeared more sensitive to hormone exposure during early gonadal development. They showed significantly altered expression of *dmrt1, cyp19a, cyp17, star,* and *esr1* with exposure to either androgens or estrogens from 10 - 20 days post hatch (dph), whereas males only showed significant responses in expression of star and esr1. Similar patterns of expression changes were seen in an exposure of fathead minnows from embryo to 20 dph to a mixture of chemicals in a laboratory setting similar to those found at concentrated animal feeding operation impacted sites as with estrogen exposure. The studies presented here can serve as a starting point to the investigation to gain a clearer understanding of how exogenous hormones and chemical mixtures impact endocrine function in fish at during development.
Keywords: Fathead minnows, Hormones, Endocrine disruption.

LENTERS, J.D.[1], SPENCE, C.[2], BLANKEN, P.D.[3], HANES, J.[4], HEDSTROM, N.[2], SUYKER, A.[5], VAN CLEAVE, K.[5], and WANG, J.[6], [1]LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108; [2]Environment Canada, Saskatoon, SK; [3]University of Colorado-Boulder, Boulder, CO; [4]Northern Michigan University, Marquette, MI; [5]University of Nebraska-Lincoln, Lincoln, NE; [6]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI. **Lake Superior's Air, Water, and Ice: Seasonal Interactions Among Evaporation, Water Temperature, and Ice Cover on the World's Largest Lake.**

Lake Superior, the largest freshwater lake in the world by surface area, has significant impacts on the regional weather and climate. In this study, we explore the interactions among Lake Superior ice cover, water temperature, and evaporation across seasonal and interannual timescales using historical model simulations and direct observations of ice cover, water temperature, and latent heat flux. Contrary to what is often expected for inland water bodies, evaporation and ice cover do not show a simple, inverse relationship. Rather, seasonal feedbacks and temporal lags lead to complex interactions among multiple variables. Thus, the net impact of ice cover on annual evaporation totals is often muted and complex. Quantifying these seasonal feedbacks and interactions is important for assessing the potential impacts of future climate change on large-lake systems. This study includes an analysis of the first direct observations of

evaporation rates on the Great Lakes, using eddy covariance data collected from monitoring stations on Granite Island and Stannard Rock (north of Marquette, Michigan). The data are analyzed over multi-year periods to explore seasonal and interannual variations in latent and sensible heat fluxes over Lake Superior, as well as some of the primary climatic factors driving this variability. *Keywords: Atmosphere-lake interaction, Ice, Lake Superior.*

<u>LENZ, B.E.</u>, New York Power Authority, 123 Main St., White Plains, NY, 10601. **Lake Sturgeon Spawning Beds in the St. Lawrence River near Waddington and Massena, NY.**

Two pairs of artificial lake sturgeon (Acipenser fulvescens) spawning beds were built in the St. Lawrence River near Waddington and Massena, NY during 2007 and 2012, respectively. Each bed is approximately 900 square m; 0.3 m thick; and consists of 5-10 cm diameter crushed stone. Eight to 10 large boulders were deployed just downstream of each bed to serve as velocity refugia. The depth of water at each location varies from 9 to 12 m and current velocities range from 0.80 to 1.5 m/s. Substrate material was installed in locations absent of zebra mussel and filamentous algae. Every spawning season since 2008, hundreds of sturgeon have been consistently observed with underwater video cameras at the Waddington beds. Distinct peaks in sturgeon abundance generally occurred the first week of June each year when water temperatures approached 16°C. Egg trap and larval drift net collections subsequently confirmed successful reproduction on the beds. Future plans are to continue to monitor the beds at both locations for sturgeon use, monitor the substrate for sedimentation/siltation, algal growth and zebra mussel colonization. Knowledge gained from these efforts can provide a blueprint for future lake sturgeon spawning beds. *Keywords: Habitats, Lake sturgeon, Spawning.*

<u>LEON, L.F.</u>, BOOTY, W., LAWRENCE, J., SEGLENIEKS, F., WONG, I., MCCRIMMON, C., and FONG, P., Environment Canada, Burlington, ON. **Review and Analysis of Loading Patterns from Detailed Inflow Datasets in Lake Erie (implications for modeling and more...).**

Integrating watershed and lake modeling requires detailed flow and loading information. Outputs from watershed models are used as inputs to feed into lake hydrodynamic and transport equations. Usually water quality data is not sampled with the necessary periodicity and efforts to set up a watershed model are constrained by the fact that available data is usually too scarce to validate the models with the required detail. In order to help recent modeling integration efforts in Southern Ontario watersheds, a very detailed set of inflow and water quality data from Heidelberg College for the Ohio river discharges (West-Central/West Lake Erie) was used to identify patterns in the long and detailed time series (e.g., 9 years: 4,314 samples: >1/day). The analysis aimed to cross-compare with watershed modeling efforts in Lake Ontario under Environment Canada Great Lakes research programs: Great Lakes Action Plan V (GLAPV) and Great Lakes Nutrients Initiative (GLNI). Examining the data at the level of drainage and yearly loading ratios, resulting values were consistent between basins and by including a variable range analysis of bio-available fractions of soluble and particulate phosphorus, patterns and group

responses where identified that might impact the way non-point source pollution and urban contributions are currently modeled. *Keywords: Watersheds, Nutrients, Model studies.*

LEON, L.F., BOOTY, W., WONG, I., MCCRIMMON, C., and FONG, P., Environment Canada, Burlington, ON. **Watershed Modeled Loads: Input for Lake Models, Application in a Lake Ontario Pilot Study Area.**

Duffins Creek was selected as a pilot watershed, on the north shore of Lake Ontario, to be analyzed with the Soil and Water Assessment Tool. SWAT is a widely known watershed model, which provides estimates of runoff, sediment yield, and nutrient loads at a sub-basin level. Here we examine the application in a mostly agricultural watershed and show the ability of the model to simulate flow discharges and monthly estimated loads for nutrients and sediments with the same level of uncertainty as other loading methods. Nash-Sutcliffe Efficiency coefficient (NSE) is used to evaluate the performance of the calibrated model and methods. Loads are compared to the National Water Research Institute (NWRI) hybrid algorithm and with Event Mean Concentrations (EMC) methods for monthly load estimates. An example of scenario testing is presented to hypothetically evaluate the effect on the increase of temperature and rainfall intensity-frequency derived from published climate change worst case scenarios.
Keywords: Watersheds, Nutrients, Model studies.

LESHKEVICH, G.[1], NGHIEM, S.V.[2], HALL, D.K.[3], and MAILLET, A.[4], [1]NOAA/Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108; [2]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA, 91109; [3]NASA/Goddard Space Flight Center, Cryospheric Sciences Laboratory, Greenbelt, MD, 20771; [4]Canadian Coast Guard, 520 Exmouth Street, Sarnia, ON, N7T 8B1. **Multi-sensor Approach to Ice Type Classification and Ice Thickness Measurement in the Great Lakes.**

Initial validation of a satellite synthetic aperture radar (SAR) algorithm to classify Great Lakes ice types showed that the algorithm correctly classified ice types using a library of ice backscatter signatures, but that open water was often misclassified owing to the ambiguity encountered in single polarization data due to variations in wind speed/direction over water. Radarsat-2 polarimetric (Quad-pol) data was used to first create an ice/water mask for both small and large incidence angle satellite SAR data. However, detecting ice/water can still be problematic using Radarsat ScanSARWide data owing to the wide range of incident angles in the data. Using Moderate-resolution Imaging Spectroradiometer (MODIS) thermal data to determine ice vs. water in these scenes with subsequent SAR ice type classification using the ice backscatter library can remediate the ambiguity. Moreover, ice thickness is needed for operational ice breaking and for modeling ice growth and transport. Until satellite algorithms for ice thickness retrieval are developed, flying a ground penetrating radar (GPR) to acquire transects of ice thickness can provide more data quicker than traditional methods. In 2012, using a helicopter-mounted GPR, test flights over lake ice were made to determine optimum altitude, and accurate ice thicknesses were obtained. *Keywords: Remote sensing, Ice, Satellite technology.*

LESHT, B.M.[1], BARBIERO, R.P.[2], WARREN, G.J.[3], and JOHENGEN, T.H.[4], [1]CSC and University of Illinois at Chicago, Chicago, IL; [2]CSC and Loyola University of Chicago, Chicago, IL; [3]USEPA/GLNPO, Chicago, IL; [4]University of Michigan - CILER, Ann Arbor, MI.
Comparison of MODIS Chlorophyll Retrievals Made Using a Tuned Band-ratio Model with a New Independent Data Set.

We used chlorophyll observations collected during the U.S. Environmental Protection Agency's Great Lakes National Program Office's (GLNPO) 2012 monitoring survey to assess the performance of the recently published Great Lakes Fit (GLF) empirical band-ratio chlorophyll retrieval model which was based on a fit to data collected between 2002 and 2011. Of the 156 locations sampled by GLNPO in 2012, we were able to match 86 (17 Erie, 25 Huron, 11 Michigan, 11 Ontario, 22 Superior) with MODIS imagery that satisfied our criteria for data quality and absence of cloud and were collected within one day of the field sampling. The relationship between the observed chlorophyll values and the matching calculated maximum band ratios for the 2012 samples was indistinguishable from the relationship found for the 2002-2011 samples. The lowest matched chlorophyll values measured in 2012, however, were lower than those that were observed between 2002 and 2011, extending beyond the range of the values we used to determine the original GLF model coefficients. Although chlorophyll estimates made by using the original GLF 3rd order model were generally satisfactory, the model over-predicted the lowest 2012 field values. The estimation was improved throughout the range when the GLF was refit to a 4th order model based on the merged 2002-2012. *Keywords: Remote sensing, Observing systems, Phytoplankton.*

LETCHER, R.J.[1], MARTIN, P.A.[2], and CHEN, D.[3], [1]Environment Canada, Ecotoxicology and Wildlife Health Division, National Wildlife Research Centre, Carleton University, Ottawa, ON, K1A 0H3; [2]Environment Canada, Ecotoxicology and Wildlife Health Division, Burlington, ON, L7R 4A6; [3]Cooperative Wildlife Research Laboratory and Department of Zoology, Southern Illinois University Carbondale, Carbondale, IL, 62901. **Comparison of Organic Flame Retardants Including Organophosphates in Eggs of European Starlings and Herring Gulls from Sites in the Western-Southern Lake Ontario Region.**

Flame retardant (FRs) are contaminants in the Great Lakes, but there is a dearth of information for terrestrial ecosystems, avian species and/or many emerging organic FRs (OFRs). We examined and compared a large suite of OFRs, fourteen polybrominated diphenyl ethers (PBDEs) and thirty-one emerging non-PBDE (e.g. organophosphate (OP)) FRs, in eggs (collected in 2009 to 2011) of European starlings (*Sturnus vulgaris*) (EUSTs; terrestrial consumers) and herring gulls (*Larus argentatus*) (HERGs; mainly aquatic consumers) from several nest box or breeding colony sites in the western-southern Lake Ontario region. For EUSTs, many OFRs were not detectable, and ΣPBDEs dominated (BDE-47, -85, -99, -100, -138, -153, -154, -183 and -209; means of 6.9 to 61.4 ng/g wet weight (ww)) with lesser Dechlorane Plus (DP; 0.2 to 2.2 ng/g ww) and tris(2-butoxyethyl)phosphate (TBEP; 0.6 to 2.0 ng/g ww) concentrations. Similar to EUSTs, many OFRs for HERG eggs were not detectable, and PBDEs and a lesser extent DPs dominated. Typically, TBEP, tris(2-chloroethyl)phosphate (TCEP) and tris(2-chloropropyl)phosphate (TCPP) were present at ΣOPFR levels of 2.1 ng/g ww. OFR levels

and trends are influenced by diet (terrestrial vs. aquatic), in ovo transfer, metabolism, feeding/migration, and/or proximity to urban and/or landfill sources. *Keywords: Environmental contaminants, Organic flame retardants, Avian ecology, Terrestrial-feeding, PBTs, Aquatic-feeding.*

LIEBIG, J.R., VANDERPLOEG, H.A., LANG, G.A., CAVALETTO, J., RUTHERFORD, E.S., RUBERG, S.A., and CONSTANT, S.A., NOAA Great Lakes Environmental Research Laboratory, 4840 S, State Road, Ann Arbor, MI, 48108. **Diel Vertical Migration Patterns in Lakes Michigan and Huron Observed at Fine Spatial and Temporal Scales Using the Laser Optical Plankton Counter.**

Spatial structure of zooplankton is a key determinant of trophic interactions in aquatic ecosystems. In Lakes Michigan and Huron, recent changes in water clarity, and phytoplankton concentration and distribution driven by dreissenid mussel filtration suggest the potential for changing patterns of spatio-temporal zooplankton structure. Using the fine-scale measuring capabilities of the Laser Optical Plankton Counter (LOPC), we examine the offshore vertical spatial distribution of zooplankton (LOPC size classes) for Lake Michigan in 2010-11 and Lake Huron in 2012. As a whole, the zooplankton structure and migration pattern is the same in both lakes. Zooplankton biomass is concentrated in the metalimnion to upper hypolimnion during the day and in the mid to upper epilimnion at night. However, when looking at different species or size classes of zooplankton, there are some distinct differences between the lakes in size/species structure and migration behavior. We discuss some of the implications of our results for trophic interactions, and directions for future monitoring and research. *Keywords: Zooplankton, Vertical spatial distribution, Lake Huron, Laser Optical Plankton Counter, Lake Michigan.*

LIU, P.C., NOAA/GLERL, 4840 S. State Rd., Ann Arbor, MI, 48108. **On a Dave Schwab legacy -- the GLERL/Donelan Wave Model.**

As one who participated in the early stage of the development of the GLERL/Donelan wave model and an interested observer throughout, I wish to recapitulate the continuous and indispensable contributions Dave Schwab made in the wave model's development and success. As the model is now an integral part of the Great Lakes Forecast System, and the model results have been used as the standard for testing and improving the new generation of main-stream wave models for the Great Lakes, I think we all would be happily offer Dave a hearty gratitude for his efforts and hard works that he has almost single handedly making the GLERL/Donelan wave model a legendary achievement. *Keywords: Waves, Model studies, Air-water interfaces.*

LIVINGSTON, S.J., SMITH, D.R., HUANG, C., and HEATHMAN, G.C., 275 S. Russell St., West Lafayette, IN, 47906. **An Alternative Management Practice to Improve Water Quality in Farmed Closed Depressional Areas.**

Closed depressions are a common feature in many young glacial till landscapes. Glacial till soils are among the most productive in the world, and thus to maximize agricultural production, many depressions are farmed. However, these areas must be drained of surface water in order to be effectively farmed. One of the most common methods to drain the surface water from depressions is by using a pipe (commonly referred to as a tile riser or tile inlet) that conveys surface water directly from the depression to a stream, even though there may be > ½ mile between the two. An alternative management practice has been tested at the field and watershed scale in the St. Joseph River watershed, northeast Indiana, United States. This practice, known as a blind inlet, is basically dense network of subsurface tile drains located in a bed of gravel that has been encased in geotextile, and has been built so that farm equipment can operate over the structure. At the field scale in 2010, sediment loading was reduced by as much as 79%, soluble and total phosphorus have been decreased by more than 70%, and nitrogen has been reduced by 24 to 59%. In early 2010, all (13) of the tile risers in a small, 750 ac watershed were replaced with blind inlets. The correlation between discharge and total phosphorus indicates that after i
Keywords: Management, Watersheds, Water quality.

LIZNICK, K. and BRANFIREUN, B., University of Western Ontario, 1151 Richmond Street, London, ON, N6A 3K7. **Explaining the Increasing Mercury Trend in Lake Erie: the Role of Invasive Species.**

Long-term monitoring has revealed a recent increasing trend in mercury (Hg) levels in the top predatory fish of Lake Erie, despite a decline in regional atmospheric Hg emissions since the early 1970s. Although organismal concentrations of Hg are expected to decrease concurrently, the availability of Hg in certain aquatic ecosystems is complicated by factors beyond emission rates. Elemental Hg and its methylated form (MeHg) elicit many adverse health effects in humans and wildlife populations. This project explored the roles that recently introduced invaders, such as the round goby and dreissenid mussel, play in the transfer of Hg and MeHg throughout the lake-wide food web. δ15N isotope ratios were used to examine changes in trophic status, and these data were coupled with Hg analyses of biotic and abiotic lake components. Preliminary results show that aqueous total and methyl Hg levels are low, often beneath EPA and instrument detection level. Depth profiles of Hg and MeHg revealed little in this shallow, well-mixed lake. Measured Hg concentrations in goby, yellow perch and walleye corresponded with literature values, indicating an inter-basin difference from West to East. Findings analyzed with the perspective of trophic transfer from lower foodweb compartments may clarify the rate of transfer and factors of biomagnification. *Keywords: Biomagnification, Lake Erie, Mercury.*

LODGE, D.M., Environnmental Change Initiative, University of Notre Dame, Notre Dame, IN, 46556. **Risk Assessment for Intentionally Introduced Species: Scientific Progress and Policy Challenges.**

At the national and regional levels, policy has not caught up to recent technical improvements in risk assessments for invasive species. For species proposed for intentional introduction (e.g., pet, watergarden, live food, or live bait industries), an opportunity exists to make decisions about whether or under what conditions to allow commerce in a given species, based on the association of species traits with the probability of harmful impact. Such risk assessments can be equally useful in evaluating alternative management actions designed to prevent the spread of species into new ecosystems (e.g., Asian carps into the Great Lakes). Evaluations of the likelihood of harmful impact of recently developed risk assessment tools for plants, molluscs, fishes and other taxa are typically 75%-90% accurate. Recent analyses show that because the cost of development and implementation of these tools is low, their use is likely to bring substantial net economic benefits as well as improved environmental protection. To maximize the benefit of such tools in the Great Lakes basin, however, the weakest link problem must be overcome. Recent interactions at the science-policy interface, and the renewed Great Lakes Water Quality Agreement, point toward improved use of species risk assessments.
Keywords: Water quality, Invasive species, Risk assessment.

LOFGREN, B.M., NOAA/Great Lakes Env Research Lab, 4840 S. State Rd., Ann Arbor, MI, 48108. **The New Normal? Water Budget and Thermal Structure Projections Under Climate Change Using CHARM.**

While increasing temperatures of air and oceans at the global scale caused by greenhouse gas emissions by humans are virtually certain, the level of certainty diminishes when considering more specific regions and impacts other than temperature. One method of addressing this issue is to use global general circulation models (GCMs) to drive regional climate models (RCMs). This has the advantage of making the results more regionally specific while maintaining two-way coupling between the atmosphere and the surface features of the region. The Coupled Hydrosphere-Atmosphere Research Model (CHARM) is an RCM developed especially for the Great Lakes Basin. Based on the combination of CHARM with the Canadian Centre for Climate Modeling and Analysis GCM, air temperature increases by about 3 degrees C over the region over an 80-year period. Precipitation generally increases, particularly in the lake effect zones during the winter. The net amount of precipitation minus evapotranspiration varies by location, and the sign of its change averaged over the basin is quite uncertain. Thermal stratification is enhanced, with thermoclines forming earlier in the season and strengthening as the season progresses. *Keywords: Climate change, Water budget, Thermal structure.*

LOUGHNER, J.L. and GALAROWICZ, T.L., 217 Brooks Hall, Central Michigan University, Mount Pleasant, MI, 48858. **Lake Huron Beach Community and Habitat Assessment.**

Lake Huron has undergone dramatic shifts in fish community composition as a result of invasive species introductions and food web changes. In particular, zebra mussels and round gobies have greatly impacted near-shore fish communities. Our objective was to assess near-shore fish communities of western Lake Huron and compare species composition post invasion to species composition in 1993, prior to the invasion of zebra mussels and round gobies. Beach fish communities were sampled by nighttime beach seining during spring and summer 2012. In addition we compared species composition between rocky and sandy beach habitats using minnow traps and modified fyke nets in fall 2012. Species abundance has declined since the pre-invasion period and species composition has also shifted from an alewife and smelt dominated community to a round goby and minnow dominated community. There are also differences in species abundance across substrate types, as a higher abundance of spotfin shiners, emerald shiners, and sand shiners are found at sites with predominantly sandy substrate. The observed shift in species composition is largely due to the introduction of invasive species; however, decreased water levels and anthropogenic impacts are also likely to be contributing factors.
Keywords: Lake Huron, Populations, Habitats.

LUCIDO, J.M., BOOTH, N.L., READ, J.S., and BLODGETT, D.L., U.S. Geological Survey Center for Integrated Data Analytics (CIDA), 8505 Research Way, Middleton, WI, 53562.
Making USGS Great Lakes Scientific Data Discoverable and Accessible Through an Integrated, Standards-Based Data Network.

The number of agencies and organizations conducting monitoring and modeling efforts in the Great Lakes combined with the vast array of resulting data types and formats presents a significant challenge for data integration. The USGS Center for Integrated Data Analytics (CIDA) is collaborating with investigators and other partners to vet emerging data standards and to develop a network that provides efficient data discovery and access. The network is comprised of real-time standards-based web services, a digital repository for discrete data and a geospatially referenced metadata catalog. This catalog acts as a central broker for discovery and dissemination of scientific data, allowing users to access and interact with real-time data streams, discrete sampling records, modeling results and reports. The digital repository provides a location to store and make available discrete data sets that do not fit into existing enterprise data systems referenced thematically, spatially and temporally. By integrating multidisciplinary monitoring data and models that encompass much of the Great Lakes basin environment, the USGS GLRI Data Network will enable policy makers to plan and evaluate restoration activities based on science that holistically represents the Great Lakes ecosystem. *Keywords: Decision making, Data Management, Standards Oriented Architecture, Data Access.*

LUDSIN, S.A.[1], ANDERSON, E.J.[2], BRODNIK, R.[1], DEVANNA, K.M.[1], CARREON-MARTINEZ, L.[3], FRYER, B.J.[4], HEATH, D.D.[4], REICHERT, J.M.[5], and FRAKER, M.E.[1], [1]Aquatic Ecology Lab, Ohio State University, Columbus, OH, 43212; [2]NOAA-GLERL, Ann Arbor, MI; [3]UT-Brownsville, Brownsville, TX; [4]GLIER, University of Windsor, Windsor, ON; [5]ORISE, Washington, DC. **Particle Backtracking as a Tool to Improve Stock Discrimination Capabilities in Mixed Populations: An Example with Lake Erie Yellow Perch.**

Management agencies seek to quantify the relative contributions of different stocks to their mixed-stock fisheries. Otolith microchemistry and genetics are often employed as tools for this purpose, wherein larvae captured in spawning locations are used to generate natal-site "signatures," which are used to determine the origins of recruits to the mixed population. This approach assumes that larvae originated at their capture location, which could reduce discrimination capabilities if untrue. Herein, we use geo-referenced individual larval yellow perch (*Perca flavescens*) hatch date and age data (from otoliths) and water circulation information from western Lake Erie (2006-2007) to show how a hydrodynamic model can be used in particle "backtracking" mode to test where larvae originated by retracing dispersal paths prior to capture. Finding that not all larvae originate in their collection locations, we then show how re-assigning larvae to their most probable natal site (based on probabilistic dispersal trajectories) can improve our ability to discriminate among stocks better than the use of otolith microchemistry and genetics alone. We also demonstrate that not accounting for dispersal of larvae prior to collection can affect estimates of relative stock contributions to the mixed population. *Keywords: Hydrodynamic model, Stock discrimination, Yellow perch, Otolith, Fish populations, Microsatellite.*

LUMIBAO, C.Y.[1], MCLACHLAN, J.S.[1], KUCH, M.[3], EMRICH, S.[2], JACKSON, S.[4], and POINAR, H.[3], [1]Department of Biological Sciences, University of Notre Dame, Notre Dame, IN, 46556; [2]Department of Computer Science and Engineering, University of Notre Dame, Notre Dame, IN, 46556; [3]Department of Anthropology, McMaster University, Hamilton, ON, L8S 4L9; [4]Southwest Climate Science Center, Tucson, AZ, 85721. **Genetic Tool for Understanding Long-term Forest Changes: Analysis of Ancient DNA from Lake Sediments.**

Paleoecological reconstructions based on fossil pollen records show that climate was the main driver of shifts in forest community composition in North America. Such long-term records are necessary to make better prediction of forest responses to future climatic changes. However, inherent limitations to pollen analysis (long-distance dispersal and similarities in pollen morphotypes) can potentially limit the inferences we can make about long-term forest changes. We present a genetic tool that can address these limitations: chloroplast DNA preserved in lake sediments for thousands of years. We extracted chloroplast DNA from lake sediments as old as 6,000 years in Upper Michigan. To examine tree species composition across different time periods, probes/baits were designed to capture ancient DNA fragments from multiple species in sediments. Results suggest the potential of ancient DNA for elucidating long-term forest changes as we can reliably distinguish different species across different time periods. For example, we identified the presence of multiple tree taxa (e.g. Fagus, Quercus, Acer, Betula)from bulk sediments and macrofossils from ~ 2,000 year-old lake sediments. These results provide a better

and more comprehensive signal for reconstruction of past shifts in forest community. *Keywords: Sediments, Paleoecology, Cores, Ancient DNA.*

LUPI, F.[1], WEICKSEL, S.[1], and DEMPSEY, D.[2], [1]301b Ag Hall, Michigan State University, East Lansing, MI, 48824-1039; [2]2000 L Street, NW Suite #615, International Joint Commission, Washington, DC, 20440. **Reviewing the Economic Benefits and Costs of Reducing Harmful Algal Bloom Reduction on Lake Erie.**

We review available information on economic benefits and costs of reducing harmful algal blooms (HABs) on Lake Erie. Given data limitations, we focus on Ohio. Benefits of HAB reduction are the economic damages avoided by reducing HAB frequency and severity. Available data enabled us to quantify about $520,000 in annual HAB damages for increased drinking water treatment costs, HAB-related illnesses, and recreation losses from beach advisories. Due to tremendous information gaps, we also discuss the many other losses that could not be quantified such as potential damages to property values, commercial fishing, recreational fishing, boating, and the broader tourism industry. HAB reduction costs are estimated for implementing agricultural best management practices (BMPs) to reduce dissolved reactive phosphorous (DRP) in Western Lake Erie. Due to uncertainty about response of HABs to DRP reductions, we estimate costs for a range of scenarios with varying levels of BMP adoption. Scenarios projected to double the DRP-reducing BMPs cost $19 to $36 million/year. Future research should address costs and benefits that lack information, especially lagged impacts on future tourism and water-based recreation, as well as costs of DRP reductions from point and nonpoint sources from urban and suburban areas. *Keywords: Harmful algal blooms, Economic evaluation, Lake Erie.*

LYNCH, M.A., University of Michigan, School of Natural Resources and Environment, 440 Church St, Ann Arbor, MI, 48109. **Assessment of Wetland Habitat Use by Juvenile Fishes, with a Focus on Rock Bass *Ambloplites rupestris* Within the St Clair River Delta, MI, USA.**

Juvenile fish were sampled across nine sites within the St Clair River delta in an effort to describe the community, determine the usage of bay habitats as nursery grounds, and assess the short-term growth of rock bass *Ambloplites rupestris*. Fish were collected from May through August, and in October in both 2011 and 2012 using hoop nets and minnow traps in sites along the Middle Channel and its connected bays. The general trends showed CPUE highest in October and June, and rock bass accounted for almost 50% of the catch and were cosmopolitan throughout the system. CPUE and rare species richness were greater at the bay sites than at the channel sites, and fish species richness was correlated with vegetation species richness, which was also higher in bay habitats. While community associations varied by site and month throughout the summer, bay habitats consistently had higher abundance and diversity of YOY fish, indicating that these habitats may be critical nursery grounds and should be highlighted as conservation and restoration priorities. Growth of YOY rock bass was assessed using RNA:DNA ratios, and was highest in the bay sites, and in late summer, indicating that these nursery grounds

may be beneficial to growth, and that growth rates fluctuate seasonally. *Keywords: St. Clair River, Habitats, Fish.*

MA, Y.[1], PETRICH, N.T.[2], VENIER, M.[1], SALAMOVA, A.[1], HU, D.[2], SPAK, S.N.[2], HORNBUCKLE, K.C.[2], and HITES, R.A.[1], [1]School of Public and Environmental Affairs, Indiana University, Bloomington, IN, 47405; [2]Department of Civil and Environmental Engineering, University of Iowa, Iowa City, IA, 52242. **Identification and Measurement on Organophosphorus Flame Retardants in Chicago's Atmosphere.**

Because of the environmental persistence, bioaccumulation and toxicity of halogenated flame retardants, organophosphorus flame retardants (OPFRs) provide an alternative choice for the flame retardant industry. We report here the identification and quantitation of several commonly used OPFRs [tributyl phosphate, tris(2-chloroethyl)phosphate, triphenyl phosphate, tris(1-chloro-2-propyl)phosphate, tri-o-tolyl-phosphate, tri-p-tolyl-phosphate, tri(butoxyethyl)phosphate, tris(1,3-dichloro-2-propyl)phosphate, tris(2-ethylhexyl)phosphate, tris(4-butylphenyl)phosphate, tris(3,5-dimethylphenyl)-phosphate, tris(2-isopropylphenyl)phosphate, and tris(2,3-dibromopropyl)phosphate] in the atmosphere of the greater Chicago, Illinois, area. Passive samplers equipped with polyurethane foam (PUF) absorbents were deployed for six weeks since the middle of 2012. Samples were collected from surrounding rural areas, from downtown Chicago, and from two water-intake cribs located about 5 km east of the Lake Michigan shoreline. Our measured atmospheric concentrations of these compounds are 1-2 orders of magnitude higher than those of brominated flame retardants, which we also measured in this study. The levels of the OPFRs are expected to further increase as the polybrominated aromatic flame retardants are phased out of production and sale.
Keywords: IADN, Environmental contaminants, Organic compounds.

MACUIANE, M.A., HECKY, R.E., and GUILDFORD, S.J., University of Minnesota/Large Lakes Observatory, Duluth, MN, 55812. **Changes in fish community structure associated with cage aquaculture farming in Lake Malawi.**

Local fishermen claim that introduction of a commercial cage aquaculture farm in Lake Malawi resulted in low fish catches as fish take refuge in the farm. This study was conducted in three sites, one at the farm and two 5 km away from it. Fish community and water quality parameters were sampled in February, April, June, and August 2012. ANOSIM tests confirm significant differences in spatial ($R = 0.472$, $p=0.005$) and temporal ($R=0.472$, $p=0.004$) changes in fish community. The two sites away from the farm were similar ($R=0.250$, $p=0.225$) but a different fish community occurred at the farm ($R=0.563$, $p=0.037$) which had more fish species and total individuals. The species accounting most for the dissimilarity were Ctenopharynx intermedius, Copadichromis chrysonotus, Lethrinops lethrinus, and Otopharynx auromarginatus. Sites were most similar in August probably due to strong windy season. Overall, water temperature, chlorophyll a, dissolved and percent dissolved oxygen follow a seasonal pattern but seem not to affect the fish community. Abundance/biomass comparison classed the farm site and

one other site as disturbed likely due to the farm operations and high fishing pressure respectively. *Keywords: Fish farming, Fish aggregations, Fisheries management.*

MADENJIAN, C.P.[1], POTHOVEN, S.A.[2], FAHNENSTIEL, G.L.[2], NALEPA, T.F.[3], VANDERPLOEG, H.A.[3], BUNNELL, D.B.[1], WARNER, D.M.[1], and TSEHAYE, I.[4], [1]USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105; [2]NOAA Great Lakes Environmental Research Laboratory, Lake Michigan Field Station, Muskegon, MI, 49441; [3]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Road, Ann Arbor, MI, 48108; [4]Michigan State University, Quantitative Fisheries Center, East Lansing, MI, 48824.
Changes in the Lake Michigan food web following the dreissenid mussel invasions.

We examined the changes in the Lake Michigan food web following the dreissenid mussel invasions, and identified those changes most likely attributable to these invasions, using the available time series for Lake Michigan and treating Lake Superior as a control lake, given that the dreissenid mussels have not successfully invaded Lake Superior. The expansion of the quagga mussel into the offshore waters appeared to have had a substantial top-down effect on both phytoplankton abundance and primary production, with annual primary production being reduced by about 35%. Although zooplankton community structure underwent significant changes, total zooplankton biomass in the offshore waters appeared to be unaffected by the invasions. The drastic decline in *Diporeia* abundance in Lake Michigan during the 1990s and 2000s has been attributed to dreissenid mussel effects, but the exact mechanism by which the mussels were negatively affecting *Diporeia* abundance remains unknown. In turn, the decreased *Diporeia* abundance has led to reduced condition, growth, and/or energy density in alewife, lake whitefish, deepwater sculpin, and bloater. To quantify the bottom-up effects of the dreissenid mussel invasions on fish abundance, additional surveillance along with a continuation of across-lakes comparisons will be needed. *Keywords: Biological invasions, Food chains, Diporeia.*

MAGHREBI, M.[1], NALLEY, D.[2], BULKLEY, J.W.[3], and BRUCE, J.P.[4], [1]SUNY at Buffalo, Buffalo, NY; [2]McGill University, Montreal, QC; [3]University of Michigan, Ann Arbor; [4]co-chair Public Interest Advisory Group of IUGLS, Ottawa, ON. **Water Quantity and the Great Lakes St. Lawrence River Basin.**

This paper aims to assess the state of water quantity - mainly by looking at the water levels - in the Great Lakes basin in its past, current, and future conditions.Analyses of historical records of water levels in the basin and the flow in the connecting channels since 1960 are presented. The variability in the main components that make up the water balance of the basin over the years is also discussed (i.e. precipitation, runoff, and evaporation). Influential factors affecting the variability of water levels in the basin are presented in two categories:(1) natural processes- these include the basin's overlake precipitation, runoff, groundwater recharge, evaporation, surface water temperature, ice cover, wind, and Glacial Isostatic Adjustment,(2) human influences - these include the consumptive water use (by different interests), lake-level regulations, and water diversions occurring in the system. Finally, looking forward tothe next 50 years - into 2060 - given the uncertainty in the water level, we introduced three plausible future scenarios.What happens if: (1)the water level rises (water availability exceeds the demands)? (2)water demands and water levels remain at status quo?(3)the water level drops (insufficient water to meet the demands)?The implications of each scenario are qualitatively discussed. *Keywords: Great Lakes basin, Water quantity, Water level fluctuations, Natural processes, Anthropogenic activities.*

MAHLER, B.J. and VAN METRE, B.J., U.S. Geological Survey, 1505 Ferguson Lane, Austin, TX, 78751. **Pavement Sealcoat, PAHs, and the Environment: An Overview.**

Studies have demonstrated that coal-tar-based sealcoat (CT sealcoat)--marketed to protect and beautify the asphalt pavement of driveways and parking lots primarily in the central, southern, and northeastern U.S.--contributes polycyclic aromatic hydrocarbons (PAHs) to streams and lakes, air, and homes. CT sealcoat typically is 20 to 35 percent coal-tar pitch and contains from 50,000 to 100,000 mg/kg PAHs, about 1,000 times more than does asphalt-based sealcoat. Where the coal-tar-based product is primarily used, PAH concentrations in dust from sealcoated pavement are about 1,000 times higher than where the asphalt-based formulation is primarily used (median total PAH concentrations 2,200 and 2.1 mg/kg, respectively). Use of CT sealcoat has several implications for the Great Lakes region. Toxicity of runoff from CT-sealcoated pavement, demonstrated for a cladoceran (*Ceriodaphnia dubia*) and fathead minnows (*Pimephales promelas*), continues for at least several weeks following application. Accumulation of PAH-contaminated sediment in stormwater detention ponds collecting runoff from CT-sealcoated parking lots can greatly increase costs for disposal. Finally, source apportionment modeling indicates that, where use of CT sealcoat is prevalent, sealcoat contributes the majority of the PAHs in lake sediment. *Keywords: Urban watersheds, Pavement, PAHs, Runoff, Sediment quality.*

MAITLAND, B.[1], FARHA, S.[1], ISAACS, N.[2], HAACK, S.[2], DARNTON, R.[1], SMITH, K.[1], and RILEY, S.[1], [1]U.S. Geological Survey, Great Lakes Science Center, Ann Arbor, MI; [2]U.S. Geological Survey, Michigan Water Science Center, Lansing, MI. **Is the Invasive Round Goby, *Neogobius melanostomus*, Facilitating Mass Bird Die-offs Related to Type E Botulism Intoxication? Evidence from Sleeping Bear Dunes National Lakeshore.**

Periodic outbreaks of type E botulism have resulted in die-offs of fish and fish-eating birds in the Laurentian Great Lakes since at least the 1960s. However, outbreaks have become more common and widespread since 1999. As part of a larger effort to investigate the dynamics of type E botulinum toxin production and distribution, the diets of the invasive Round Goby, *Neogobius melanostomus*, were examined, and stomach contents were tested by quantitative polymerase chain reaction (qPCR) to assess their role as a toxin vector. Round gobies were sampled during April-November 2011 using minnow traps and gillnets at depths of 10-20m at four nearshore sites near Sleeping Bear Dunes National Lakeshore on Lake Michigan. In total, 568 round gobies from 2011 were used in diet composition analyses. Important prey items by frequency of occurrence for round goby in 2011 were Harpactocoid copepods (20.7%), *Dreissena* spp. (19.02%), and Ostracods (14.75%). Preliminary results suggest the bontE gene can be detected in selected fish stomach contents. A synthesis of results to date, exploring spatio-temporal patterns in diet, will be presented. *Keywords: Round goby, Diets, Great Lakes Restoration Initiative (GLRI).*

MAJARREIS, J.M.[1], WATSON, S.B.[2], and SMITH, R.E.H.[1], [1]Department of Biology ESC 350, University of Waterloo 200 University Ave. W., Waterloo, ON, N2L 3G1; [2]National Water Research Institute, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Differentiating Group-Specific Phytoplankton Phosphorus Status Using Nutrient-Induced Fluorescent Transient (NIFT) Variable Fluorescence Responses.**

Monitoring tools need to be developed to quickly determine what role nutrients, especially phosphorus (P), might play in potentially toxigenic cyanobacteria bloom formation. Other phytoplankton groups may become P-starved if cyanobacteria can out-compete them for P. Nutrient-induced fluorescent transients (NIFTs) are a pattern of chlorophyll a fluorescence unique to nutrient-starved phytoplankton that are resupplied with the previously growth-limiting nutrient. Mixtures of lab-grown *Microcystis aeruginosa* and *Asterionella formosa* cultures were assessed in a 2x2 factorial design of P-sufficient and P-deficient mixtures. PhytoPAM, a pulse amplitude modulated (PAM) fluorometer that can infer phytoplankton groups, measured group-specific Fv/Fm at intervals for ~1h. Cultures that were previously P-sufficient did not have statistically different Fv/Fm before and after resupply of phosphate. Previously P-deficient *M. aeruginosa* showed the characteristic NIFT response: a rapid drop and slow rise in Fv/Fm. *A. formosa* responded with a slight rise in Fv/Fm in response to addition of phosphate. This is one of the first studies to demonstrate the ability of this instrument and method to detect and differentiate P-deficiency between two phytoplankton groups, and could be a valuable water quality monitoring tool. *Keywords: Nutrient-induced fluorescent transient (NIFT), Phosphorus, Variable fluorescence, Microcystis, Phytoplankton.*

MALINICH, T.D., PANGLE, K.L., and ZHENG, T., Central Michigan University, Mount Pleasant, MI, 48858. **The Impacts of Active Movement on Pelagic Larval Dispersal in a Great Lake.**

Physical advection has the potential to disperse Great Lakes larval fish tens to hundreds of kilometers and thus may strongly influence larval growth, survival and the connectivity of local populations. To investigate how active movement of larvae may alter such passive dispersal, we have developed a model of yellow perch (*Perca flavescens*) larval movement in Lake Michigan, to which we added simple and complex rules of behavior (e.g. directional, homing and gradient attractions) shown to be generally important in marine systems. We found that active movement at conservatively low swimming speeds greatly impacted dispersal predictions through changes in total displacement, final location, and the spread among individuals emanating from the same location. For example, larvae which orient to swim towards or away from their origin can lead to an 80% increase or 70% decrease, respectively, in predicted mean displacement relative to passive drift. We observed spatial variation in active movement where impacts on larvae within the southern basin exceeded the northern basin. Our results

demonstrate the potentially large effect of active movement on long-distance dispersal of Great Lakes fish populations and prioritizes specific behaviors and associated environmental cues to be tested in future lab and field experiments. *Keywords: Fish behavior, Hydrodynamic model, Populations.*

MANDELIA, A.J., URBAN, N.R., PERLINGER, J.A., SCHWAIGER, E.M., and MACLENNAN, C.A., Michigan Technological University, Houghton, MI, 49931. **Analysis of PCB Contamination in the Torch Lake Area of Concern.**

In the Torch Lake Area of Concern, two beneficial use impairments (BUI) remain: degraded benthos and fish consumption advisories. Until recently, the polychlorinated biphenyl (PCB) contamination in Torch Lake (which affects the fish consumption BUI) has been considered widespread and unmanageable. Little effort had been made to identify the source of the PCB contamination or assess its movement from Torch Lake into connecting waters. Our compilation and analysis of PCB data measured by the Michigan Department of Environmental Quality (MDEQ) and the U.S. Environmental Protection Agency (U.S. EPA) have identified PCB contamination "hot spots". Congener analysis of the sample data suggests that the PCB source is heavier than the atmospheric source of PCBs to area surface waters. The PCB analyses show that likely hot spots are located along the northwestern shore of Torch Lake. Analysis of historical copper mining and processing activities in the area suggests that the hot spots were the likely result of disposal of electrical equipment or fluids used in stamp mills or the local power generation and distribution system. In addition, the PCB congener distributions in fish tissue samples analyzed by the MDEQ indicate that the bioaccumulation of PCBs from Torch Lake is localized. *Keywords: PCBs, Area of Concern, Mining.*

MANZO, L.M.[1], FORTNER, R.W.[2], and DIERKES, C.[1], [1]Ohio Sea Grant, 1314 Kinnear Road, Columbus, OH, 43212; [2]113 Paula Circle, Oak Island, NC, 28465. **Teaching Great Lakes Climate Science in a Changing World.**

The 2011-12 Great Lakes winter was the 4th warmest in a century of recorded weather, capping off a year of record low snowfall amounts and drought conditions through most of 2011. The area now faces lower lake levels that impact shipping and shoreline land values, and create fisheries issues, wetland loss, migratory bird flyway changes, and favorable conditions for invasive species. Now is a critical time for educators to take steps to increase climate change awareness and knowledge, as well as introduce skills that encourage Great Lakes stewardship. This presentation will provide an overview of twelve new and updated lessons for integrating climate change research with environmental science concepts in middle and high school. Designed collaboratively with teachers and scientists, the lessons serve as a model for Great Lakes curriculum development. Innovative methods for addressing Great Lakes climate change issues in classrooms combine science content with archived and real-time data, focus on the 5 Es for effective lesson delivery, incorporate educational technology, and align with *Climate* and *Great Lakes Literacy Principles,* as well as the national *Framework for K-12 Science Education*.

Examples of successful classroom implementation strategies will also be shared.
Keywords: Environmental education, Climate change, Education.

MAREK, R.F., MARTINEZ, A., and HORNBUCKLE, K.C., Dept. Civil and Environmental Engineering, IIHR-Hydroscience and Engineering, The University of Iowa, Iowa City, IA, 52242. **PCB Metabolites in Sediment and Porewater in a Lake Michigan Waterway.**

The industrial community of East Chicago, IN, USA is bisected by the Indiana Harbor and Ship Canal (IHSC). Branching off Lake Michigan, the IHSC waterway is designated as an Area of Concern by the International Joint Commission and is a major source of PCBs to Lake Michigan. PCBs can be metabolized by humans and other organisms to the hydroxylated form (OH-PCBs), and researchers have shown that OH-PCBs affect brain development and function and are endocrine disruptors. It is likely that PCBs in the IHSC sediment are metabolized to OH-PCBs by microbial activity, which may be a removal mechanism for PCBs in sediment. OH-PCBs may also come from exogenous sources such as wastewater treatment plants. While OH-PCBs are widely reported in humans and other animals, they have not yet been reported in sediment. We hypothesized that OH-PCBs are present in the contaminated IHSC sediment and developed a method for the extraction and GC-MS-MS analysis of 65 OH-PCBs in sediment and sediment porewater. We analyzed sediment and porewater samples collected in 2006 and 2009. PCB results have already been published for these samples. Our measurements help us understand the fate and transport of these toxic compounds. *Keywords: Lake Michigan, PCBs, Sediments.*

MARIN JARRIN, J.R.[1], PANGLE, K.L.[1], XIA, M.[2], LUDSIN, S.A.[3], MASON, D.M.[4], and RUTHERFORD, E.S.[4], [1]Central Michigan University, Department of Biology, Mount Pleasant, MI, 48859; [2]University of Maryland Eastern Shore, Department of Natural Sciences, Princess Anne, MD, 21853; [3]The Ohio State University, 1314 Kinnear Road, Columbus, OH, 43212; [4]NOAA GLERL, 4840 S. State Rd., Ann Arbor, MI, 48108. **Linking River Discharge and Wind-Driven Currents to the Success of Larval Yellow Perch in Western Lake Erie.**

Yellow perch (*Perca flavescens*) is an economically and ecologically important species across the Great Lakes that exhibits highly variable recruitment. In western Lake Erie, this variability appears to be driven largely by the Maumee River plume, which creates advantageous habitat for larvae. To better understand the processes underlying this plume effect, we used field observations and a coupled physical-biological model to i) evaluate the effects of river discharge and wind-driven currents on the creation and expansion of high-quality nursery habitat and ii) examine the role of water currents in moving larvae into and out of the plume. We found that high discharge events did not always lead to a large plume, due to a strong interaction between discharge and open-lake circulation. Further, rather than facilitating larval retention, currents were predicted to passively advect larvae out of the plume at surprisingly high rates. Predicted residency durations (< 2 weeks) were shorter than observed residency durations (> 1 month) estimated using otolith microchemistry of larvae collected from within the plume. The discrepancy suggests that active movement behavior allows larvae to remain within plumes. We

discuss the implications of these findings to understanding fish recruitment both in Lake Erie and beyond. *Keywords: Hydrodynamic model, River plume, Yellow perch, Passive transport, Watersheds.*

MARKLE, C.E.K. and CHOW-FRASER, P., McMaster University, 1280 Main Street West, Hamilton, ON, L8S4K1. **Comparing approaches to model habitat suitability for Blanding's turtles (*Emydoidea blandingii*) in the Georgian Bay archipelago.**

Since conservation plans for the Blanding's turtle, a threatened species in the Great Lakes, are empirically derived they will be most effective for areas where extensive research has been conducted. For the Georgian Bay archipelago, where Blanding's turtles have been found, research on habitat use has been limited. Published habitat suitability (HS) models are not directly applicable to this region, and lack of a HS model for the archipelago is limiting the development of effective conservation strategies. Although species distribution modelling has been around since the 1970's, statistical techniques and accuracy of implemented methods continue to advance. Since a variety of methods (e.g. statistical models, machine learning) are available and best practices remain uncertain, we conducted a study to evaluate several methods. First, we used field data collected from Beausoleil Island in 2011 and 2012 as well as data consolidated from the literature to determine which source of data is more accurate in predicting HS. Second, we used several methods to produce HS models to determine which is most accurate. Overall, we aim to develop an accurate HS model for the Blanding's turtle of the Georgian Bay archipelago, and apply this to identify islands for protection without the need for extensive and costly field surveys. *Keywords: Conservation, Georgian Bay, GIS.*

MARSDEN, J.E.[1], JOHNSON, J.E.[2], DINGLEDINE, N.[3], and ADAMS, J.[4], [1]81 Carrigan Dr., University of Vermont, Burlington, VT, 05405; [2]Alpena Fisheries Research Station, 160 E. Fletcher, Alpena, MI, 49707; [3]DLZ Michigan, 1425 Keystone Ave., Lansing, MI, 48911; [4]Michigan Department of Environmental Quality, Remediation Division, 2100 West M-32, Gaylord, MI, 49735. **Artificial Reefs as a Restoration Tool in Thunder Bay, Lake Huron.**

In 2010 and 2011, 29 artificial reefs were constructed in Thunder Bay, Lake Huron, to mitigate degradation of a natural spawning reef and improve spawning success of lake trout and lake whitefish. Reefs were designed to study characteristics that attract spawning lake trout and maximize egg incubation success. All reefs were composed of angular cobble-rubble material, with steep sides. Twenty-four reefs were 23 m long and 10 m wide, in two arrays, each with three replicates of height (1.5 and 3 m) and orientation (SW-NW and SE-NW). Four reefs were small (10 m diameter) to test effect of reef size. Hydrosondes within the reefs monitor overwinter DO. Reef attraction was evaluated by assessment of adult spawner density, egg density, lake trout fry abundance, and lake whitefish larval density, compared with two natural reefs. Data were collected for two years prior to construction, and, to date, two years post-construction. Colonization of reefs by periphyton, dreissenids, and macroinvertebrates was monitored. In fall, 2012, movements of 40 lake trout were tracked by acoustic telemetry. Lake whitefish have spawned extensively on the reefs since construction, but lake trout attraction did not occur until

the second year post-construction. Results show potential for artificial reefs to enhance native species restoration. *Keywords: Lake trout, Lake Huron, Fish populations.*

MARSDEN, J.E., 81 Carrigan Dr., University of Vermont, Burlington, VT, 05405. **How to Handle the Interview.**

As an applicant, you've passed the first two hurdles - finding a job or graduate position that interests you, and impressing the employer/professor sufficiently, on paper, to get an interview. Now you need to show the potential advisor, or employer, that you are the right person for the job. In preparation, you will want to know what types of questions you will likely be asked. You will need to do your homework, and learn about the employer or the university/lab to which you are applying. Equally importantly, though sometimes overlooked in the eagerness to gain a position, you need to interview them - is this the right job/graduate project for you? Do you want to work with this person? Are there sufficient resources to do the project? What do the other graduate students/employees say about the lab, or job? After the interview, follow up with a thank you, and know that if this job does not come through, you are now better prepared for the next interview. *Keywords: Education.*

MARTIN, E.K.[1], GALAROWICZ, T.L.[1], CLAPP, D.F.[2], and CLEVENGER, J.[2], [1]Department of Biology, Central Michigan University, Mount Pleasant, MI, 48858; [2]Charlevoix Fisheries Research Station, Michigan Department of Natural Resources, Charlevoix, MI, 49720. **A comparison of recent and historical time periods: Changes in the smallmouth bass population of Waugoshance Point, northern Lake Michigan.**

Smallmouth bass populations in nearshore waters of northern Lake Michigan were historically considered a premier sport fishery. Historical research on the movement, abundance, reproduction, and growth of a smallmouth bass population in northern Lake Michigan was performed in the 1950s at Waugoshance Point. Since the 1950's, regulations have changed, including increases in length limits. In addition, Waugoshance Point has added a catch-and-release angling season. The objective of this study was to perform a population assessment to determine if and how this smallmouth bass population has changed since the 1950s. Sampling was performed in June 2009-2011 and May and July 2012 using trap net surveys, similar to the historic study. Though total catch of smallmouth bass is similar to that of the 1950s, catch-per-unit-effort, length distributions, and age-at-length have increased. High relative weights have also been observed, indicating good condition of individuals captured. Based on current results, it appears that the smallmouth bass population at Waugoshance Point has changed in a positive way since the 1950s. These results provide recent information on the population dynamics and an update on the status of the smallmouth bass fishery at Waugoshance Point.
Keywords: Smallmouth bass, Lake Michigan, Fish populations.

MARTIN, L. and BADE, D.L., Kent State University, Kent, OH, 44242. **Indicators of Phosphorus Limitation in Nearshore to Offshore Transects in Lake Erie.**

Based on the nearshore phosphorus shunt hypothesis, we predicted that phosphorus limitation should be more severe in offshore regions than in nearshore regions of Lake Erie. Water samples were taken from eight nearshore to offshore transects across the lake in June and August of 2011 and 2012. We measured three indicators of phosphorus limitation, the phosphorus debt assay, the phosphorus turnover time assay, and the alkaline phosphatase assay. It was rare that any significant trends were observed along the transects. Evidence for much strong phosphorus limitation was not widely observed in these assays, except in the alkaline phosphatase assay. Seasonal differences, however, were observed, with increasing phosphorus limitation observed in August. This suggests that in the more eutrophic conditions of Lake Erie, the effects predicted by the nearshore phosphorus shunt are not widely evident.
Keywords: Phosphorus, Eutrophication, Algae.

MARTIN, S.L.[1], HAYES, D.B.[2], KENDALL, A.D.[1], RUTLEDGE, D.T.[3], PIJANOWSKI, B.C.[4], and HYNDMAN, D.[1], [1]Michigan State University, Dept. of Geological Sciences, East Lansing; [2]Michigan State University, Dept. of Fisheries and Wildlife, East Lansing, MI; [3]Manaaki Whenua Landcare Research, New Zealand; [4]Purdue University, Dept of Forestry and Natural Resources, West Lafayette, IN. **Land-use legacies and ecosystem tipping points.**

We explore relationships between LULC and ecosystem responses. Specifically, we link mechanistic models of groundwater flow to a time series of LULC to create a land use legacy map. We then use this temporally explicit representation of land use to explore relationships to water chemistry in aquatic ecosystems. We hypothesize that: 1) chemicals with high solubility will have stronger relationships with legacy land uses via groundwater flow paths than those with low solubility, which are affected more by surficial transport processes; 2) chemicals with low biological reactivity will have a stronger link to groundwater flow paths than those with high biological reactivity (e.g. nitrogen and phosphorus). Our results show that there are areas with long groundwater pathways that represent different LULCs than exist on the landscape today.
Keywords: Ecosystem modeling, Nutrients, Hydrologic cycle.

MARTINEZ, A.[1], PETRICH, N.T.[1], SPARK, S.N.[2], HU, D.[1], CARMICHAEL, G.R.[3], and HORNBUCKLE, K.C.[1], [1]4105 Seamans Center for the Engineering Arts and Sciences, Iowa City, IA, 52242; [2]310 South Grand Ave, Iowa City, IA, 52242; [3]3100 Seamans Center for the Engineering Arts and Sciences, Iowa City, IA, 52242. **Dispersion Modeling of PCB Airborne Emissions from the Indiana Harbor and Ship Canal into the local Atmosphere.**

In a previous study we determined that the Indiana Harbor and Ship Canal (IHSC) is a source of polychlorinated biphenyls (PCBs) to the air above it. We hypothesized that the PCBs emitted to the air over the IHSC are continuously dispersed into the surrounding atmosphere. We addressed this hypothesis by using an atmospheric dispersion model, AERMOD. This model allowed us to predict hourly air concentration of total and individual PCB congeners (~160) for

the year 2008. In addition, we employed the Weather Research and Forecasting Model (WFR) to predict local vertical as well horizontal hourly meteorological conditions at a fine grid scale (1.3 km). Performance of the model was assessed using active air samplers for nine months of 2008. Results show that the IHSC is not only a source of airborne PCBs to East Chicago, but also to Lake Michigan. Annual average air concentrations of total PCBs ranged from 2.5 to 250 pg m-3. We also found a strong effect of the local meteorological conditions into the dispersion and transport of these chemicals during the year. For example, period of times with low planetary boundary layer and high vertical convective velocity yielded high concentrations.
Keywords: Spatial distribution, Atmosphere-lake interaction, PCBs.

MARTY, J.[1], POWER, M.[2], and PLANAS, D.[3], [1]Genivar, 2611 Queensview Drive, Ottawa, ON, K2B 8K2; [2]University of Waterloo, 200 University West, Waterloo, ON, N2L 3G1; [3]Université du Québec à Montréal, 201 Président Kennedy, Montreal, QC, H2X 3Y7. **Authochtonous versus allochthonous food sources supporting aquatic food webs: lessons from altered ecosystems.**

Over the last decade, several stable isotope studies have highlighted the importance of terrestrial carbon supporting aquatic food webs. In this study, carbon stable isotope data were collected to evaluate the main food source supporting the food webs of 3 distinct ecosystems: boreal lakes and reservoirs, regulated rivers and the Great Lakes nearshore zone facing the impact of a new invader. Considering altered food webs allowed to better separate the influence of both algal and terrestrial food source by increasing the variation in carbon signatures of consummers. The relationship between algal and consumers signatures carbon signatures was strong in all ecosystems, with a slope not significantly different than 1. This result indicates that despite abundant terrestrial subsidy, algal carbon remains the main food source supporting aquatic food webs. On the other hand, terrestrial subsidies may still play a key role in the functionning of the aquatic ecosystems as a source of nutrients or as a substrate supporting algal growth. *Keywords: Stable isotopes, Food chains, Algae.*

MASON, D.M.[1], ZHANG, H.[2], RUTHERFORD, E.S.[1], IVAN, L.N.[2], BELETSKY, D.[2], ADAMACK, A.T.[3], HOFF, M.[4], FULTON, E.A.[5], BARBIERO, R.P.[6], and GORTON, R.J.[5], [1]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 48108; [2]University of Michigan, Ann Arbor, MI, 48108; [3]University of Canberra, Canberra, Australia; [4]US Fish and Wildlife Services, Ft. Snelling, MN; [5]CSIRO Division of Marine and Atmosphere Research, Hobart, Australia; [6]CSC/Loyola University Chicago, Chicago, IL. **Forecasting Asian Carp Impacts On Lake Michigan's Food Web And Fisheries - Using The Atlantis Ecosystem Model.**

Bighead (*Hypophthalmichthys nobilis*) and silver (*H. molitrix*) carp (AC, Asian carps) have the potential to invade the Great Lakes and may disrupt food webs and fisheries through the consumption of lower trophic levels. However, these potential impacts vary amongst habitats (i.e., offshore, nearshore, drown river mouths and tributaries). To account for habitat heterogeneity, we are using the Atlantis modeling framework which incorporates spatially

explicit 3-D information on biological (food web), geochemical, and physical processes and simulates the potential food web consequences as a function of stressors (e.g., AC invasion). The model was forced by nutrient inputs, daily flow fields and water temperature from a 3D hydrodynamic model, and calibrated (without AC) with available abundance/biomass time series of modeled groups. AC was then added to the food web to forecast impacts for a range of scenarios: three AC biomass levels (none, low and high) and high/low nutrient loading. By comparing the differences amongst forecasts, we assessed the likely impacts of AC on food webs, and production, recruitment and harvest of key prey and predator fish species among Lake Michigan habitats. *Keywords: Fish, Ecosystem modeling, Lake Michigan.*

MASON, L.A.[1], RISENG, C.M.[2], FORSYTH, D.K.[1], SPARKS-JACKSON, B.L.[2], WANG, L.[3], RUTHERFORD, E.S.[4], WEHRLY, K.E.[1], MCKENNA, JR., J.E.[5], CASTIGLIONE, C.[6], JOHNSON, L.B.[7], and SOWA, S.P.[8], [1]Institute for Fisheries Research, State of Michigan DNR, University of Michigan, 1109 N. University, 212 Museums Annex Bldg., Ann Arbor, MI, 48109; [2]University of Michigan, SNRE, 440 Church St., Ann Arbor, MI, 48109; [3]International Joint Commission, 100 Ouellette Ave., 8th Floor, Windsor, ON, N9A 6T3; [4]NOAA-GLERL, 4840 S. State Rd., Ann Arbor, MI, 48108; [5]Tunison Laboratory of Aquatic Science, US Geological Survey, 3075 Gracie Road, Cortland, NY, 13045; [6]U.S. Fish and Wildlife Service, Lower Great Lakes Fish and Wildlife Conservation Office, 1101 Casey Rd., Basom, NY, 14013; [7]Natural Resources Research Institute, University of Minnesota, 5013 Miller Trunk Highway, Duluth, MN, 55811; [8]The Nature Conservancy, 101 E. Grand River Ave., Lansing, MI, 48906. **Great Lakes Aquatic Habitat Framework: Creating a common spatial grid for sharing physical, geochemical, and biological data across the entire Great Lakes Basin.**

GLAHF is a project focusing on the development of a database and classification that integrates key habitat components to address restoration and management needs in the Great Lakes basin. GLAHF has encountered many challenges with data sharing, management, formats, and spatial and temporal variations throughout the project. We have remedied some of these challenges by cross-walking bi-national datasets, compiling point sampling data, and calculating new variables. Land use/cover layers and others have been cross-walked to create contiguous bi-national datasets. A major effort has been to delineate watersheds across the entire basin using a consistent watershed definition to standardize the summary of landscape influences on the nearshore. To create more complete point sampling datasets we compiled water chemistry measurements from various sources by common strata and depths, and summarized biological data with consistent metrics. Raw and modeled data, in numerous time steps have been processed to create calculated variables, such as upwelling from daily surface temperature. GLAHF is leveraging these datasets and many others to create a basinwide aquatic habitat classification focused on the nearshore environment. Viewing and delivery of the classification and supporting datasets will be made public via geoportal. *Keywords: GIS, Data acquisition, Great Lakes basin.*

MASSON, C., 2-341 Laird Drive, Toronto, ON, M4G 3T0. **Respond with Awareness, Commit to Opportunity: Towards a Regional Vision for the Great Lakes and St. Lawrence River.**

In bold language, a strategic vision ties the present to the future. Environmental vision statements articulate shared desired futures for nature and people. The purpose of this comprehensive inquiry is to describe and facilitate effective use of vision statements and organizing principles across the Canada-United States Great Lakes and St. Lawrence River basin, and other transboundary, intergovernmental regions by entities having a primary organizational focus on ecological integrity, sustainable development and/or social justice. Over 2000 entities, their statements, plans, programs and reports were assembled from a wide range of publicly available sources. Using logic models, grounded theory and literature searches, attention is directed to systemic comparison and coding of normative, cognitive, instrumental and motive content deployed within declarative statements. The study locates interacting, multi-faceted legislative, discipline/sector, spatial, temporal and hybrid standpoints within a general taxonomy that may serve to advance broad understanding of high-level strategic planning for the environment. The goal is to design and populate a practical tool to guide development of integrated, intra-jurisdictional, consensus-based visioning processes towards achievable outcomes within a risk-opportunity management framework. *Keywords: Environmental policy, Vision statements, St. Lawrence River, Transboundary governance, Great Lakes basin, Operating principles.*

MATHEWS, L.K.[1], GALAROWICZ, T.L.[1], JONAS, J.L.[2], and PANGLE, K.L.[1], [1]Department of Biology, Central Michigan University, Mount Pleasant, MI, 48859; [2]Charlevoix Fisheries Research Station, 96 Grant Street, Charlevoix, MI, 49720. **Truss type morphometric comparison of lake trout from Elk Lake (Antrim County), lean forms from Lake Superior, and stocked lean forms from Lake Michigan.**

Elk Lake is a small inland lake located in Antrim County, Michigan. It was hydrologically separated from Lake Michigan during the mid 19th century and contains a self-sustaining population of lake trout (Salvelinus namaycush). Assessments in 2011-2012 indicate that lake trout in Elk Lake are occupying deep water when spawning, similar to native forms of lake trout no longer found in the Great Lakes. The objectives of this study were to determine if the Elk Lake lake trout are morphologically different than lean forms of lake trout in Lake Superior and stocked forms in Lake Michigan. Sampling in Elk Lake consisted of gill netting in deep water (80-200 feet) during Fall 2011 and 2012, and Spring 2012. A truss-type morphometric analysis was used to compare the Elk Lake, Lake Michigan, and Lake Superior populations. Also, a creel survey and angler diary program was instituted during Summer 2012 to determine the impact of anglers on Elk Lake. Results for the truss analysis indicated distinct morphological differences between the three populations, which is supported by genetic analysis differentiating Elk Lake forms from stocked forms in Lake Michigan and lean forms in Lake Superior. Preliminary data from the creel survey and angler diary program suggests angling does not have a large impact on the lake trout population in Elk Lake. *Keywords: Lake trout, Morphometrics, Elk Lake.*

MATISOFF, G.[1], WATSON, S.B.[2], and GUO, J.[2], [1]Dept. Earth, Environmental and Planetary Sciences, Case Western Reserve University, Cleveland, OH, 44106-7216; [2]Watershed Hydrology and Ecology Research Division, Environment Canada, Burlington, ON, L7R 4A6.
Sediment Resuspension in Lake Winnipeg.

There has been a dramatic rise in severe algal blooms in Lake Winnipeg, attributed to increased nutrient inputs from the watershed. Much of this external loading is associated with suspended particles but the transport and fate of this nutrient fraction within the lake and the importance of internal loading via resuspension is unknown. We employed 7Be and 210Pb activities of suspended matter in tributaries, in the lake water column, in sediment traps and in bottom sediments over the 2012 season to estimate the fractions of suspended matter derived from the watershed and resuspended from the bottom. 7Be activity in suspended sediments was higher than in bottom sediments or in material from the Red River, suggesting another source of 7Be to the suspended matter (e.g. direct precipitation onto the lake). Comparing long term sedimentation rates in dated cores with the seasonal sediment accumulation in the sediment traps indicated that over 87% of suspended matter in the water column was resuspended bottom sediment. A 2-component mixing model using the 7Be/210Pb ratio in each potential sediment source indicated that resuspension of bottom sediment accounted >97% of the suspended material in the water column. *Keywords: Sediment resuspension, Radioisotopes, Tributaries.*

MATSUMOTO, K.[1], TOKOS, K.[1], and GREGORY, C.[2], [1]Department of Earth Sciences, University of Minnesota, Minneapolis, MN, 55455; [2]University of Michigan, Ann Arbor, MI, 48109. **A Model Investigation of the Ventilation Time of Lake Superior Using Artificial Dye Tracers.**

Understanding how surface waters ventilate the interior of Lake Superior can help determine the fate of various natural and anthropogenic inputs to the lake. Even though Lake Superior is dimictic and therefore the lake overturns twice a year, some parts of the lake may not be fully ventilated and contain "old water." In the ocean, for example, bottom topography constricts flow and thus slows ventilation in some parts of the deep ocean. In this study, we use two types of passive tracers, an age tracer and a concentration tracer, in a realistically configured numerical model of Lake Superior to characterize its interior ventilation. The tracers allow us to determine the evolution and the frequency distribution of the ventilation age everywhere in the model domain. Our preliminary results suggest that the deepest parts of the lake require up to two years to fully ventilate, while most other parts ventilate well within a year. *Keywords: Lake Superior, Ventilation, Model studies, Mixing.*

MAVROMMATI, G., BAUSTIAN, M.M., and DREELIN, E., Center for Water Sciences, Michigan State University, 301 Manly Miles Building, 1405 S. Harrison Rd, East Lansing, MI, 48824. **A Conceptual Framework for Coupling Socioeconomic and Lake Systems: the Case Study of the western shore of Lake St. Clair, North America.**

We propose an interdisciplinary conceptual framework for linking the socioeconomic system in the Clinton River watershed to the ecosystem of western shore of Lake St. Clair (LSC). Key components driving the interactions between socioeconomic and lake systems were investigated with respect to water sustainability, maintenance of ecosystem services, and the incorporation of knowledge and field experience from stakeholders. Our analysis reveals four pathways that include human activities of water use and discharge, land use, tourism and shipping/transporting that impact the ecological condition of LSC. We also examined how LSC affects human well-being through the provision of ecosystem services related to water quality. A casual loop diagram illustrating the relationships and feedbacks between socioeconomic activities, pollutants and ecosystem services is presented. This conceptual framework can be used to help communicate to stakeholders and help scientists build dynamic models to quantitatively investigate the interactions and feedbacks. *Keywords: Lake St. Clair, Ecosystem services, Pollutants, Human activities, Water quality, Stakeholders.*

MAY, C.J., LUDSIN, S.A., and MARSCHALL, E.A., The Ohio State University Aquatic Ecology Lab, 1314 Kinnear Rd. Area 200, Columbus, OH, 43212. **Does available growth environment predict walleye recruitment in western Lake Erie?**

Management agencies desire the ability to understand recruitment variation in their fisheries. Because growth and survival during early life stages can strongly influence future recruitment to the fishery, we explored if the springtime growth environment experienced by larval walleye (Sander vitreus) is a strong predictor of juvenile abundance during summer. We hypothesized that a good larval growth environment would positively correlate with both juvenile length and abundance. Towards this end, we used in situ measurements of prey availability and temperature in a spatially-explicit, bioenergetics-based model to create an index of larval Growth Rate Potential (GRP) during spring 1994-2011. We created a function to estimate foraging rate using water clarity and larval diet data. Our analyses demonstrate that observed juvenile abundance was positively correlated with GRP during spring, but that growth was negatively correlated to it. These results suggest the existence of density-dependent growth. Inshore GRP also was greater than offshore GRP and positively correlated with springtime Maumee River discharge, pointing to a role for watershed inputs in the recruitment process. Our findings highlight the need to consider biophysical regulatory mechanisms during early life when trying to understand recruitment variation. *Keywords: Bioenergetics, Recruitment, Walleye.*

MCCOY, C.A., 77 W Jackson Blvd (G-17J), Chicago, IL, 60604. **Making the Invisible Visible: Engaging Schoolchildren in Great Lakes Legacy Act Remediation.**

Illinois-Indiana Sea Grant piloted an educational program with two schools in the Grand Calumet River Area of Concern (AOC) in Northwest Indiana. The purpose was to connect local youth to the river, build scientific literacy, and teach students about the nearby Great Lakes Legacy Act (GLLA) sediment remediation project. The challenge was to make a scientifically complex and seemingly "invisible" problem like contaminated sediment "visible" and relevant to schoolchildren. Programming began in early February 2012 and culminated in June with student participation at a U.S. Environmental Protection Agency press event for the GLLA. Teacher feedback concluded the most effective lessons incorporated hands-on activities and visual demonstrations. With lessons learned from the pilot, this program is being refined and carried out in additional Great Lakes AOCs. In October 2012, we delivered revised programming in the Sheboygan River AOC. Through a series of structured presentations, engaging activities, field trips, and stewardship projects thus far, more than 800 students have become familiar with ecological concepts and had direct interaction with GLLA remediation and restoration work. *Keywords: Sediments, Education, Public participation.*

MCCOY, C.A., 77 W. Jackson Blvd, G17-j, Chicago, IL, 60604. **Risk Communication: Lessons from Social Science.**

Risk communication practitioners can learn many lessons from the social sciences. Social science research helps us understand human nature and tells us why individuals and societies think, feel, and behave in certain ways. The social science of risk communication demonstrates how factors that agencies have some control over (e.g., trust in the agency) and do not have control over (e.g., demographics and general belief systems) can influence public risk perception of specific agency actions. It explains the frustration risk professionals feel when the public is more concerned about low-probability, high-consequence risks than high-probability, low-consequence risks. These lessons and more can help practitioners communicate more effectively with their audiences. *Keywords: Outreach, Environmental education, Risks.*

MCDONOUGH, C.A. and LOHMANN, R., University of Rhode Island Graduate School of Oceanography, 215 S. Ferry Rd., Narragansett, RI, 02882. **Detection of Emerging Persistent Bioaccumulative Toxics in the Great Lakes Using Polyethylene Passive Samplers.**

Organic pollutants, including Galaxolide and Dechlorane Plus, were detected in extracts from polyethylene passive samplers deployed in Lake Ontario and Lake Erie in 2011. Extracts were initially screened for a suite of emerging persistent bioaccumulative toxics adapted from Muir et al. (2010) using gas chromatography with mass spectrometry (GC/MS) with electron ionization (EI) and selective ion monitoring (SIM). Galaxolide, Tonalide, and Dechlorane Plus were tentatively identified during this screening. Further compound identification and quantification required more specific analyses, including tandem electron ionization mass spectrometry (GC-EI-MS/MS) in selective reaction monitoring mode (SRM). The synthetic

musk Galaxolide was present at concentrations above blank levels in the majority of aqueous samples with the highest levels measured in water samples from Toledo, Ohio and Oswego, New York. *Syn*- and *anti*- isomers of the ubiquitous high production volume chlorinated flame retardant Dechlorane Plus were identified in several air samples, with the highest levels in air at offshore sites near Buffalo, NY and Grimsby, Ontario. Spatial gradients in contaminant levels were analyzed using GIS. *Keywords: Mass spectrometry, Toxic substances, Environmental contaminants.*

MCELMURRY, S.P.[1], CONFESOR, R.B.[2], RICHARDS, R.P.[2], and MILLER, C.J.[1], [1]Dept. Civil & Environmental Engineering, Wayne State University, Detroit, MI, 48202; [2]NCWQR, Heidelberg University, Tiffin, OH, 44883. **Use of Urban BMPs to Reducing Phosphorus Loads to Lake Erie.**

Recent algal blooms within Lake Erie have renewed concern over phosphorous (P) loads from non-point sources. While the mitigation of P loads from agricultural watersheds has received significant attention, urban sources are often underappreciated. Urban runoff is the primary source of water quality impairments in many surface waters, despite comprising only a small fraction (~3%) of land mass. To mitigate the impact of urban runoff, new "green" infrastructure and best management practices (BMPs) are being deployed. Although these systems are increasingly being used, their effectiveness - particularly related to P removal - remains unclear. As part of a larger project funded by the International Joint Commission focused on addressing growing concerns over water quality within Lake Erie, a review of urban BMPs used to mitigate P loadings was conducted. Based on this review (1) few urban BMPs within the Lake Erie watershed focus on reducing P loads; (2) some urban BMPs commonly employed to reduce other pollutant loads (e.g. suspended solids) actually increase P loadings (e.g. bioswales); (3) the amount of monitoring is largely inadequate to assess urban BMP effectiveness; and (4) future monitoring efforts need to extend beyond total P concentrations and include dissolved reactive P or P speciation. *Keywords: Urban areas, Best management practices, Phosphorus, Green infrastructure, Lake Erie.*

MCKINNEY, P.J. and MATSUMOTO, K., Department of Earth Sciences, University of Minnesota, Minneapolis, MN. **Climate and basin morphology influence on thermal bar initiation and development.**

The seasonal cycle of stratification and mixing in dimictic lakes includes periods when surface water temperatures of the nearshore and offshore regions straddle the temperature of maximum density (T_{md}), roughly 4^{o} C. At the convergence of the two regions, one warmer than T_{md} and the other colder, mixing produces water at T_{md}. Known as the thermal bar, the downwelling of the dense water formed by this caballing process inhibits cross margin transport, thereby affecting nearshore water quality. Previous research indicates the onset and duration of the thermal bar period is due to a combination of heat flux, wind stress and bottom slope. The thermal bar period typically lasts for weeks in the Great Lakes, but its timing varies according to differences in meteorology and lake morphology. To improve the understanding of how these

factors influence the onset and duration of the thermal bar period, we performed sensitivity analysis using ROMS, a 3-dimensional hydrodynamic model. We used idealized basin geometries with different bottom slopes, and forcing based on Great Lakes regional climatology from 1985 - 2005 meteorological records. Our results compare the timing of thermal bar onset and its duration to perturbations in cloud cover, air temperature and wind speed and direction. *Keywords: Computer models, Hydrodynamic model, Model studies.*

MCLAUGHLIN, R.L.[1], BARBER, J.[2], CASTRO-SANTOS, T.[3], JONES, M.[4], KOOPS, M.[5], MANDRAK, N.E.[6], PRATT, T.[7], SMYTH, E.[8], and SULLIVAN, P.[9], [1]University of Guelph, Department of Integrative Biology, Guelph, ON, N1G 2W1; [2]US Fish & Wildlife Service, 3090 Wright St., Marquette, MI, 49855; [3]USGS, S.O. Conte Anadromous Fish Research Center, Turners Falls, MA, 01376; [4]Michigan State University, Quantitative Fisheries Center, East Lansing, MI, 48824; [5]Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences, Burlington, ON, L7R 4A6; [6]Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences, Burlington, ON, L7R 4A6; [7]Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences, Sault Ste. Marie, ON, P6A 2E5; [8]University of Guelph, Department of Integrative Biology, Guelph, ON, N1G 2W1; [9]Fisheries and Oceans Canada, Sea Lamprey Control Centre, Sault Ste. Marie, ON, P6A 2E5.

Controversy over Connectivity: Restoration of Migratory Fishes versus Control of Invasive Fishes.

Decisions affecting the movements of fishes migrating between a Great Lake and its tributaries can be controversial. Removing a dam or providing fish passage can assist with restoration of desirable migratory fishes, but also open up habitat to invasive species, with undesirable consequences. Constructing or maintaining in-stream barriers can restrict the movements and reproduction of invasive fishes, but with similar effects on desirable migratory fishes. Using Sea Lamprey control in the Laurentian Great Lakes as an example, we demonstrate how tensions over connectivity decisions have arisen in the past, continue to occur, and are likely to heighten in the future. These tensions can arise from two phenomena. First, the benefits of restoring native species can be overestimated if local managers and stakeholders fail to consider uncertainty in restoration outcomes, while the value of ongoing control can be underestimated due to the success of Sea Lamprey control. Second, the mosaic management structure in the Great Lakes can encourage local decision makers and stakeholders to pursue the benefits of restoring native fishes, while placing the added cost of invasive species control on neighbouring jurisdictions. Greater understanding of these phenomena will ensure that connectivity decisions are balanced and logical. *Keywords: Migrations, Restoration, Fish, Decision making.*

MCLEAN, A.R.[1], BRAVENER, G.[2], and MCLAUGHLIN, R.L.[2], [1]Department of Integrative Biology, University of Guelph, Guelph, ON, N1G 2W1; [2]Sea Lamprey Control Centre, Department of Fisheries and Oceans, Sault Ste Marie, ON. **Catch Me If You Can: Sea Lamprey (*Petromyzon marinus*) Behaviour at Traps in the St. Marys River.**

We tested three of six hypotheses for the low entrance rates of sea lamprey (*Petromyzon marinus*) into traps in the St. Marys River connecting Lakes Huron and Superior. The sea lamprey is invasive in the Great Lakes and the target of binational control. Trapping could be valuable for sea lamprey control in large rivers if trapping success is increased. We hypothesized that entrance rates were low because sea lamprey (i) failed to detect the trap opening due to complex flows near the traps (H1), (ii) could not reach the trap opening because of the swimming challenge presented by high discharge (H2), or (iii) could not enter a trap due to interference with other sea lamprey at the trap opening (H3). Video recordings of sea lamprey at traps were used to investigate how trapping success changed in response to alterations of nightly discharge through a power plant where sea lamprey are trapped. Consistent with earlier research, few sea lamprey entered traps. However, sea lamprey reached trap entrances with high probability regardless of discharge, contrary to H1 and H2. They were often at the trap opening alone, contrary to H3. Our findings demonstrate how understanding behaviour can be crucial to improving the trapping success of invasive species. *Keywords: Fish behavior, Underwater Video, Invasive species, St. Marys River.*

MCLEAN, M.W., ROSEMAN, E.F., and KENNEDY, G.W., USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105. **Review of Artificial Reefs and Reef Restoration in the Laurentian Great Lakes.**

To better understand the objectives for performance of artificial reefs and reef enhancement projects in the Laurentian Great Lakes, we conducted a literature review to glean information on these projects. Dating back over forty years, objectives of structure use have ranged from abating impacts of currents and waves, providing safe harbors, improving sportfishing opportunities, to enhancing/restoring fish spawning habitats. Reef construction methods ranged from haphazard placement of construction debris to careful restoration of native rock habit. To date, we discovered 31 artificial reef structures in open waters, connecting channels, and tributaries of the Great lakes; six in Lake Erie, seven in Lake Michigan, three in Lake Huron, two in Lake Ontario, and one in Lake Superior, as well as one in the St. Clair River, three in the Detroit River, four in the St. Lawrence River three in the Fox River, WI, and one in the Current River, Thunder Bay, ON. Levels of assessment of reef performance varied but a noticeable lack of long-term monitoring was common as was a lack of assessment for physical attributes. Our investigation underscores the need to develop standard protocols for monitoring the biological and physical attributes of artificial structures in an adaptive management framework. *Keywords: Spawning habitat, Habitats, Reef enhancement, Monitoring.*

MCMURRAY, P.D.[1], STAHL, J.R.[1], SMITH, J.R.[2], KOMINOWSKI, A.L.[2], and SPARKS, D.[3], [1]Indiana Department of Environmental Management, Office of Water Quality, 100 N. Senate Ave (MC65-40-2 Shadeland), Indianapolis, IN, 46204-2251; [2]Indiana Department of Environmental Management _OLQ/OLC, 100 N. Senate Ave - N1307, Indianapolis, IN, 46204-2251; [3]U.S. Fish & Wildlife Service - BFO, 620 South Walker Street, Bloomington, IN, 47403-2121. **Determination of Beneficial Use Impairment Delisting Potential of the Grand Calumet River Area of Concern: Benthic Macroinvertebrate Community and Sediment Toxicity Sampling and Analysis.**

More than 150 years of channelization, urbanization, industrial and chemical manufacturing have resulted in extensive degradation of the Grand Calumet River (GCR) basin, a small (175 km2) watershed in northwest Indiana flowing into southern Lake Michigan and the Illinois River Basin. The GCR basin has been designated as an Area of Concern (AOC) requiring a Remedial Action Plan to improve 12 current beneficial use impairments (BUIs). We will present our plan for sampling and analysis of benthic macroinvertebrate community and sediment toxicity samples at 20 locations in the GCR AOC in 2013 to determine if recent sediment removal and capping projects have improved the condition of the GCR. We will also present historical data to set the context of historical contamination in the GCR. Resulting data will support delisting the GCR AOC for BUIs #3 (Degradation of fish and wildlife resources), #6 (Degradation of benthos), and removal from the Indiana 303(d) list for Impaired Biotic Communities. This project is being funded through the Indiana Department of Environmental Management and the Natural Resource Damage Assessment Trust Fund.
Keywords: Macroinvertebrates, BUI's, Toxic substances, AOC, Sediments, Impaired water use.

MCNAUGHT, A.S. and RASMER, D.R., Central Michigan University, Mount Pleasant, MI, 48858. **Identifying Potential Competitors of Wild Rice (*Zizania spp.*) in Michigan Wetlands.**

Wild rice is an annual, emergent, aquatic grass that grows in isolated wetlands throughout the Midwest, and along the eastern coast of North America. Now a threatened species in much of its traditional range, adaptation and survival of wild rice may be inhibited by other forms of aquatic vegetation that are competing for the same light and nutrients. There is considerable interest in understanding best management practices that could enhance yields, and investigating community structure is critical. The objective of this study was to determine if the plant communities in wild rice sites were significantly different from the plant communities in non-wild rice sites. A total of 36 Michigan wetland sites were sampled between June and August of 2011 and 2012. The total percent cover of emergent, submergent, and floating plants were determined using a both 0.5 x 0.5 meter quadrate, and visual inspection. High abundance of emergent plants in both Upper and Lower Peninsulas suggests that wild rice coexists well with other emergent plants. This pattern was similar for both *Z. aquatica* and *Z. palustris*. High abundance of floating plants outside of rice beds in the Upper Peninsula only, suggests that floating plants may compete with wild rice for light. *Keywords: Vegetation, Competition, Wild rice, Conservation.*

MCNAUGHT, A.S.[1], THOMA, S.M.[1], MURRY, B.A.[1], and JOHNSON, J.E.[2], [1]Department of Biology, Central Michigan University, Mount Pleasant, MI, 48859; [2]Fisheries Division, Michigan DNR, Alpena, MI, 49707. **Habitat Use by Hemimysis anomala in Thunder Bay, Lake Huron.**

Following establishment of dreissenid mussels, energy flow in Lake Huron has shifted from the offshore, pelagic system to the nearshore benthic system. The recent invasion by *Hemimysis anomala* may have further altered the benthic-pelagic link. Before investigating how *Hemimysis* might alter energy flow, it is necessary to evaluate the spatial and temporal distribution of the mysid as well as its position in the nearshore food web. We collected monthly *Hemimysis* samples from 2 reef and 2 non-reef areas in Thunder Bay, Michigan, May-July, 2012 using paired 2-liter bottle traps and vertical net tows. All samples were preserved in ethanol. *Hemimysis* were counted, sexed and measured. Fish and invertebrate samples were collected in late summer and analyzed for stable isotopes (δC^{13} and δN^{15}). Our results indicate that *Hemimysis* populations are restricted to reef areas until August when dispersal occurs. *Hemimysis* were more abundant on a shallow, natural reef than a deep, artificial reef. *Hemimysis* remained near the bottom even during the night until late summer. Juveniles were more abundant than adults in early summer and females were more abundant than males. *Hemimysis* in Thunder Bay represent a strong link between benthic and pelagic food webs. *Keywords: Stable isotopes, Habitats, Invasive species.*

MELANÇON, C.[1] and FRIES, D.[1], [1]Spyglass Technologies, Inc., 101 16th Avenue South, Suite 4A, St. Petersburg, FL, 33701; [2]Spyglass Technologies, Inc., 101 16th Avenue South, Suite 4A, St. Petersburg, FL, 33701. **Real-time Water Quality Monitoring using Autonomous Portable Water Laboratories.**

This presentation will review results produced by unique water monitoring platforms invented at the Monterey Bay Aquarium Research Institute (MBARI) and the University of South Florida (USF). Spyglass water sensors and software have been deployed in open ocean and coastal environments since 2001. In situ analytical methods available on these platforms include mass spectrometry, molecular probe arrays, immuno-assays (cELISA), and quantitative Polymerase Chain Reaction (qPCR). The systems provide researchers and water-quality managers in a commercial environment rapid and real-time information on the chemistry and biology of water samples. By removing the need to manually return samples to a central laboratory, Spyglass platforms enable water-quality managers to preemptively enact alternative water treatment steps and/or initiate remediation strategies before these chemicals or microorganisms adversely impact the safety of public water sources. *Keywords: Observing systems, Biogeochemistry, Coastal ecosystems.*

METHOT, J.D.[1] and HUANG, X.[2], [1]McGill University, James Administration Building, 845 Sherbrooke Street West, Montreal, QC, H3A 0G4; [2]SUNY-Buffalo, 12 Capen Hall, Buffalo, NY, 14260. **Demographics, Societal Values, and Land Use: monitoring and envisioning change in the Great-Lakes - St. Lawrence basin.**

The footprint left by development in the Great Lakes-St. Lawrence River basin is fundamentally linked to the size, structure, and distribution of the human population across the region. We present analyses of population size and distribution, age structure, immigration, and urban land use within the Great Lakes basin, and across six sub-basins, for the period 1960-2010. In the last 50 years, the human population within the basin has become bigger (reaching 48.5 million people in 2011), older (a result of both decreasing fertility and increasing life expectancy), and more diverse (as immigrants make up a higher share of the population). A booming population on the Canadian side has stood in stark contrast to low growth or even population decline on the American side. Urban sprawl continues to outpace population growth in many areas, even for major American cities experiencing population drain. We conclude by presenting three future scenarios of change for population, land use, and societal values; and highlight the role that societal values play in shaping the state of the basin. *Keywords: Great Lakes basin, Demographics, Scenarios, Land Use.*

MILLER, B.K.[1], TEPAS, K.[1], SALAZAR, K.[2], DOUCETTE, J.S.[2], SCHOMBERG, J.[3], HART, D.[4], JAFFE, M.[5], MCCORMICK, R.[2], BREEDERLAND, M.A.[6], LUCENTE, J.[7], RAFFERTY, S.[8], and PENNY, M.[9], [1]IL-IN Sea Grant, 1101 W. Peabody Drive, 374 nsrc, Urbana, IL; [2]IL-IN Sea Grant, 1101 W. Peabody Drive, 374 nsrc, Urbana, IL; [3]Minnesota Sea Grant, 31 W.College Park, Duluth, MN; [4]Wisconsin Sea Grant, 1975 Willow Drive, Madison, WI; [5]IL-IN Sea Grant, 412 S. Peoria Street, Suite 400, Chicago, IL; [6]Michigan Sea Grant, 520 W, Front Street, Traverse City, MI; [7]Ohio Sea Grant, One Government Center, Suite 550, Toledo, OH; [8]Pennsylvania Sea Grant, 301 Peninsula Drive, Suite 3, Erie, PA; [9]New York Sea Grant, 121 Discovery Hall, SUNY at Stony Brook, Stony Brook, NY. **Engaging Great Lakes Communities to Develop Tipping Point Action Plans.**

A Great Lakes extension program and companion web-based decision support system was developed to engage community leaders in assessing their community sustainability relative to Great Lakes tipping points. Four one-night modules have been developed to help officials: 1) Explore the state of their aquatic resources 2) Examine threats to ground and surface water quality and develop an action plan 3) Identify areas key to sustaining biodiversity and develop conservation strategies 4) Identify prime farmland and protection policy options. Sea Grant extension professionals in all Great Lakes states are working collaboratively to develop this program using a web-based decision support system and programs will be delivered to communities in each Great Lakes state. *Keywords: Indicators, Decision making, Outreach.*

MILLIGAN, M.S.[1], RICHARDS, D.[1], CRIMMINS, B.[2], XIA, X.[2], HOLSEN, T.M.[2], HOPKE, P.[2], and PAGANO, J.[3], [1]SUNY Fredonia, Fredonia, NY; [2]Clarkson University, Potsdam, NY; [3]SUNY Oswego, Oswego, NY. **Non-targeted and Targeted Identification of Emerging Contaminants in Great Lakes Fish and Fish Eggs using GCxGC-TOF Mass Spectrometry.**

As part of the EPA-sponsored Great Lakes Fish Monitoring and Surveillance Program (GLFMSP), we have been employing GCxGC-TOF mass spectrometry to identify potential emerging contaminants of concern accumulating in Great Lakes fish and fish eggs. Non-targeted potential emerging contaminants were identified by comparing experimental mass spectra with NIST mass spectral library databases on a peak-by-peak basis. Several chlorinated, brominated, and fluorinated compounds have been tentatively identified using this approach, and many appear to be possible physical-chemical or biochemical degradation products derived from legacy contaminants such as PCB's, PBDE's, and organochlorine pesticides. In addition, we have also tentatively identified several organometallic and organo-phosphate based compounds accumulating in fish and eggs, which may be used as industrial catalysts or replacement flame retardants. For targeted analysis, we have generated user-defined mass spectral library databases from the Howard-Muir list of 610 potential persistent and bioaccumulative in-use chemicals, and reprocessed our GCxGC-TOF data files to search for mass spectral hits of just these compounds. Using this approach, we have tentatively identified several of these currently used commercial chemicals in Great Lakes fish and fish eggs. *Keywords: Environmental contaminants, Fish, Chemical analysis.*

MISSAGHI, S. and BILOTTA, J., 4100 220th Street W, Farmington, MI, 55024. **Measuring impacts of educational programs in meeting Clean Water Goals of our Communities.**

Educational and outreach programs are an integral part of our water resources management schemes. But there is a lack of data relating the impacts of educational programs to improved water quality. Minnesota Extension has successfully implemented two collaborative and locally tailored water resources professionals and public engagement, education and outreach programs (NEMO & Stormwater U) based on a 7 point criteria frame work of needs assessment, identifying resources, collaboration, researched based content, innovative deliveries, multi-scale evaluation, and use of technology. Training materials are developed through an iterative peer reviewed stepwise process. We will share program evaluation statistics, outputs, outcomes, impacts, and descriptions, plus a discussion on what is missing from the program and its challenges. We offer this model as an effective method of delivery and implementation of educational program that will allow communities to meet their regulatory needs as well as to insure the quality of their water resources. Finally we will share data on "credit" or load reduction contributed to this program. The purpose of this presentation is to promote and showcase educational programs that have real and direct measurable impacts on management and protection of our water resources. *Keywords: Outreach, Economic evaluation, Education.*

MISSAGHI, S., 4100 220th Street W, Farmington, MN, 55024. **Influence of fluid motion on growth rate and spatial (vertical) distribution of Microcystis aeruginosa.**

Cyanobacteria is a morphologically complex phylum of bacteria that obtain their energy through photosynthesis and are primary producers supporting fisheries and ecosystems. They are remarkably well adapted to live in a wide array of ecosystems with extreme physical and chemical conditions. The genus Microcystis is rapidly exploiting the growing number of eutrophic lakes that are fed by the excessive urban and agricultural runoff and is becoming the dominant algae in these ecosystems and forming Harmful Algae Blooms. In the natural environment Microcystis always form colonies of hundreds cells however, in usual laboratory cultures Microcystis only exist as single cells. Under laboratory conditions and using a Plankton Tower, we treated different cultures to various fluid motions. Temperature, DO, and cell density profiles were collected and growth rate and vertical Microcystis distribution measured. The presentation will highlight the findings of influence of fluid motion on growth rate and spatial (vertical) distribution of Microcystis. Plus, we will share a brief discussion on how to grow Microcystis colonies under laboratory conditions. *Keywords: Algae, Turbulence, Microcystis, Harmful algal blooms.*

MOCKLER, D.R.[1], AREND, K.K.[1], MOERKE, A.H.[1], STEINHART, G.B.[1], and RIPPLE, P.[2], [1]School of Biological Sciences, Lake Superior State University, 650 W. Easterday Ave., Sault Sainte Marie, MI, 49783; [2]Bay Mills Indian Community, 11801 Plantation Rd, Brimley, MI, 49715. **Determining if tributaries contribute energy and nutrient inputs to lake whitefish in nearshore areas of Whitefish Bay, Lake Superior, MI.**

Lake whitefish (*Coregonus clupeaformis*) are part of an important fishing industry in Whitefish Bay, Lake Superior, and are an important food resource for the Bay Mills Indian Community. Understanding tributary and nearshore energy and nutrient sources to lake whitefish can direct management efforts by identifying habitats and processes that are pertinent to lake whitefish recruitment and growth. We think that tributaries to Whitefish Bay could provide important energy and nutrient contributions to the nearshore bay food web. This study identifies contributions of tributary inputs to nearshore food web pathways that support lake whitefish in Whitefish Bay, particularly early life stages. Algal and detrital resources and invertebrate consumers were collected immediately upstream of the mouths of three tributaries: Naomikong Creek, Pendills Creek, and Tahquamenon River. Basal resources, invertebrate consumers and larval, juvenile, and adult lake whitefish were collected in tributary-influenced nearshore bay habitat and at a nearshore bay site with no tributary influence. Stable isotope analysis of $\delta^{13}C$ and $\delta^{15}N$ signatures was used to estimate the relative contributions and pathways of tributary and bay energy and nutrient sources to lake whitefish. *Keywords: Food chains, Coastal ecosystems, Lake Superior.*

MOHAIMANI, A.A., HERNANDEZ, J.J., WEIRICH, C.A., MILLER, T.R., and TONELLATO, P.J., 3209 N Maryland Ave Room 234, Milwaukee, WI, 53211. **Actionable Public Health Information from a Temporal Milwaukee Beach Water Quality Database.**

Public health authorities post advisories or close beaches based on the presence of indicator bacteria (e.g. *E. coli*). Results may be confounded by sample quality, methodology and timeliness of analysis. Environmentally-driven predictive modeling of *E. coli* at beaches may mitigate these complications, improving veracity of public health decisions. Through collaboration with the Milwaukee Health Department (MHD), we built a data Extract, Integrate, Translate and Load (EITL) process and database to support predictive modeling at Milwaukee beaches. Lake Michigan water samples were collected from three popular beaches, June to August 2012, during high public use. Levels of *E. coli* were assessed by Colilert-18 assays and qPCR. EPA guided survey data were recorded for each beach. Quality assurance through EITL produced a robust database informative for predictive modeling. Retrospective analysis, in conjunction with automated satellite data, demonstrated predictive sensitivity to thresholds for *E. coli* concentrations exceeding 83%. This work provides an automated EITL web interface markedly improving decision support systems to deliver accurate and timely actionable information for use by public health agencies. *Keywords: Actionable public health information, Water quality, Public health Informatics, Data storage and retrieval, E. coli, Decision making.*

MOHD-ROZHAN, Z.[1], HECKY, R.E.[1], GUILDFORD, S.J.[1], and WERNE, J.P.[2], [1]Large Lakes Observatory, University of Minnesota Duluth, 2205 East 5th Street, Duluth, MN, 55812; [2]Department of Geology & Planetary Science, University of Pittsburgh, 4107 O'Hara St SRCC 505, Pittsburgh, PA, 15260. **Sedimentary Fluxes in Lake Malawi (Africa) Determined Using Moored Sequential Sediment Traps.**

Information on the algal productivity and nutrient cycling regime of Lake Malawi, a long (600 km) and deep (maximum depth 700 m) rift valley lake in southern Africa is crucial for determining the water quality of the lake that sustains 1000 species of endemic cichlid fishes. Settling of particulate organic matter from the euphotic zone reflects primary productivity and nutrient fluxes and can provide continuous, remotely acquired information relatable to the physical dynamics when sediment traps are moored with thermistor chains. Moored sequential sediment traps were deployed in the upper water column at northern (175 m) and southern (125 m) sites in January 2011 for a year with 18 day collection intervals. Two distinct peaks of total mass flux were recorded during the wet and dry seasons at both locations: May and November (northern) and March and June (southern) with values ranging from 2060-2646 mg/m2/day. Biogenic Si fluxes were also maximal during these peaks but contributed only a small portion to the high mass fluxes which were dominated by mineral material. The mass flux measurements were higher than previously reported studies (1980s and 1990s) suggesting increased loadings of lithogenic materials and nutrients from the rivers during the wet season and their resuspension due to upwelling during the dry, windy season. *Keywords: Africa, Sedimentation, Productivity, Sediment traps, Nutrients, Total mass flux.*

MOORE, T.S.[1], MOUW, C.B.[2], SULLIVAN, J.M.[3], and TWARDOWSKI, M.S.[3], [1]Ocean Process Analysis Laboratory, University of New Hampshire, Durham, NH, 03824; [2]Dept. of Geological & Mining Engineering & Sciences, Michigan Technological University, Houghton, MI, 49931; [3]WET Labs, Inc., 70 Dean Knauss Dr, Narragansett, RI, 02882. **Ocean color observation in Lake Erie for HAB detection.**

We present a strategy for a new field research program to study the development and detection of harmful algal blooms (HABs) in western Lake Erie. Our research will focus on the development of bio-optical algorithms for the quantification of HAB-specific metrics using ocean color remote sensing data. This algorithm development will be supported by the deployment of an autonomous buoy in western Lake Erie to measure environmental and biological parameters. We will also be conducting multi-day spatial surveys of the region in late August that will be used for algorithm development and validation. The aim of the research is to promote the advancement of bio-optical observation and detection of HABs, along with their obtaining a greater understanding of their environmental cues that lead to and sustain bloom evolution. *Keywords: Remote sensing, Harmful algal blooms, Lake Erie.*

MORBEY, Y.E., MEMA, M., and MCLEOD, D.V., Department of Biology, Western University, London, ON, N6A 5B7. **A State-Dependent Life History Model for Lake Whitefish in Lake Huron.**

Fisheries often select for a younger age and smaller size at maturity in fishes. Whether or not this is the case for gill net fisheries in the Great Lakes has yet to be evaluated. Towards answering this question, we developed a state-dependent life history model for lake whitefish (*Coregonus clupeaformis*) in Lake Huron. This dynamic programming model considers state-dependent allocation decisions given energy intake, size-dependent fecundity, mortality risk, and the tradeoff between investing in current reproduction and achieving a larger size. We first derive optimal age and size at maturity in a model without fishing. We then analyze the sensitivity of age and size at maturity to the addition of varying levels of size-selective fishing mortality. *Keywords: Life history studies, Fisheries, Lake Huron.*

MOUW, C.B.[1] and GREB, S.[2], [1]Michigan Technological University, 1400 Townsend Drive, Houghton, MI, 49931; [2]Wisconsin Department of Natural Resources, Madison, WI. **Status and Recent Recommendations for Remote Sensing of Coastal and Inland Waters.**

Remote sensing offers one of the most spatially and temporally comprehensive tools for observing coastal and inland waters. While there has been success with remotely observing these water bodies, many challenges still remain. A NASA-sponsored workshop took place at the University of Wisconsin-Madison in June 2012 to address these challenges. The scope was limited to products that can be derived from visible spectral reflectance (aquatic color) and infrared emissivity (surface temperature) and the science considerations surrounding these products. The workshop summarized the current state of remote sensing in these complex waters, identified gaps in knowledge, data needs and priorities. A status summary, workshop outcomes and recommendations with different time frame horizons will be presented. *Keywords: Remote sensing.*

MUCHA, A.P.[1], KLEI, A.J.[2], CONLIN, T.[2], and CIENIAWSKI, S.[1], [1]U.S. EPA GLNPO, 77 W. Jackson Blvd., Chicago, IL, 60604; [2]Ohio EPA, 50 West Town Street, Suite 700, Columbus, OH, 43216-1049. **Multiple Approaches to Restoration at the Ashtabula River Area of Concern.**

The Ashtabula River AOC is a priority AOC with 6 remaining BUIs: restrictions on fish and wildlife consumption, degradation of fish and wildlife populations, degradation of benthos, loss of fish and wildlife habitat, fish tumors and deformities, and restrictions on dredging. Under the Great Lake Legacy Act, over 500,000 yds3 of contaminated sediment was dredged from the river which made significant progress towards restoration. In addition, also under GLLA, there was in water and riparian habitat restoration completed at the northern end of the 5 ½ slip. Then utilizing GLRI funds, Ohio EPA restored a larger footprint also along the 5 ½ slip. To effectively document the function of the ecosystem and to assess the status of the beneficial use impairments, in 2011 a multi-Agency sampling effort took place on the Ashtabula AOC to address multiple regulatory and AOC goals. The sampling and data collection included such measures as surface weighted average concentrations in sediment and several biotic measures. In 2012, two additional remediation projects were initated to fully restore the AOC: an additional Legacy Act project as well as a Strategic Navigation project under USACE authority to address the restrictions on dredging BUI. These data and projects will be presented as well as future steps to restore the AOC. *Keywords: Cleanup, Sediments, Habitats, Great Lakes Restoration Initiative (GLRI).*

MUIR, D.C.G.[1], TEIXEIRA, C.[1], SETT, A.[1], EPP, J.[1], WANG, X.[1], KEIR, M.[2], and BACKUS, S.M.[2], [1]Environment Canada, Aquatic Contaminants Research Division, Burlington, ON, L7R 4A6; [2]Environment Canada, Water Quality Monitoring and Surveillance, Burlington, ON, L7R 4A6. **Bioaccumulation of Selected Halogenated Organic Flame Retardants in the Great Lakes region.**

The bioaccumulation and water concentrations of a wide range of non-legacy halogenated organic compounds (HOCs) was determined in remote lakes within the Canadian shield and in the open Great Lakes. Large volume samples of surface waters (100 L) were collected from two remote lakes Lake Opeongo (ON) and Siskiwit Lake (MI) as well as from central sites in Lakes Erie and Ontario over the period 2005-2011. Zooplankton (>100 um), mysids, forage fish and lake trout were also analysed. Extracts were screened for 27 individual BDEs (Br3-Br10) and 30 Br3-Br6 compounds/ PBDE replacements and other HOCs using GC-electron capture negative ion mass spectrometry. While most analytes were near or below detection limits in Siskiwit and Opeongo, a larger suite were detectable in Erie and Lake Ontario waters including Dechlorane Plus, pentabromo-ethylbenzene (PBEB), 1,3,5-tribromo-2-methoxy-4-methylbenzene (Br3MeBz), allyl 2,4,6-tribromophenyl ether, and dibromopropyl 2,4,6-tribromophenyl ether (DPTE), 12345-pentabromobenzene (Br5Bz), and 2-ethyl-1-hexyl 2,3,4,5-tetrabromobenzoate (EHTeBB) although concentrations were near or at MDLs. A wide

range of Br3-Br6 compounds were detected in zooplankton from Lake Ontario including Br3MeBz, 1,3,5-tribromobenzene, tetrabromoxylene, bis(tribromophenoxy)ethane, PBEB, and BPTE. BDE47, BDE153 *Keywords: Bioaccumulation, Emerging chemicals, PBDEs, PBTs.*

MULVANEY, K.K.[1], FOLEY, C.J.[2], HÖÖK, T.O.[1], and PROKOPY, L.S.[1], [1]Purdue University, Department of FNR, West Lafayette, In, 47907; [2]Illinois-Indiana Sea Grant College Program, 195 Marsteller St., West Lafayette, In, 47907. **Identifying Useful and Usable Climate Change Information Needs of Great Lakes Fisheries Managers.**

As climate change researchers begin efforts to understand climate change impacts on the Laurentian Great Lakes, it is important for them to help meet the climate change information needs of resource managers. Our research initiated efforts to understand the climate change information needs of Great Lakes fisheries managers. Utilizing a mixed-methods approach that included an email survey of policy and decision makers and focus groups with the technical committees of the Great Lakes Fishery Commission, we identified a number of social and ecological research gaps that are important to Great Lakes fisheries management. Additionally, we found that although there was a recognition of the importance of research across ecological scales, the findings indicate that there is a preference for information regarding specific species of restoration effort or fishing interests. The managers indicated a need for researchers to carefully consider the usefulness of temporal and spatial scales when designing their research and presenting the information. Finally, in order to facilitate the communication of research findings from the researchers to the fisheries managers, we identified the preferred mechanisms of fisheries managers for receiving information. *Keywords: Fisheries, Social science, Climate change, Management.*

MUNAWAR, M. and FITZPATRICK, M., Fisheries & Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Microbial - Planktonic Food Web Dynamics in the Great Lakes: Changing Autotrophic and Heterotrophic Communities.**

Fisheries & Oceans Canada began comprehensive studies of the microbial - planktonic food web of the Great Lakes in the early 1990s. These included detailed microscopic analysis (epifluorescence, Utermöhl) for assessing bacteria, picoplankton, heterotrophic nanoflagellate (HNF), ciliate and phytoplankton communities as well as measurements of primary productivity and bacterial growth rates. Our results show that the structure and function of the microbial - planktonic food web varies considerably among the Great Lakes. For example, in Lake Superior, we found that ≈ 90% of the organic carbon pool was autotrophic and that smaller picoplankton (< 2 μm) was likely the dominant vector of energy transfer due to their high turnover rates (0.7 d-1). By contrast, in Lake Ontario we found that ≈ 55% of the organic carbon pool was heterotrophic (overwhelmingly HNF) and that net plankton (>20 μm) had the highest carbon turnover rates (5.9 d-1). Our findings show that microbial food webs are highly variable in the Great Lakes and the role of heterotrophs in the transfer of autochthonous production remains poorly understood. This paper will examine the natural variability of autotrophs and heterotrophs in microbial food across the Great Lakes and the importance of heterotrophs in the community composition. *Keywords: Algae, Heterotrophs, Carbon, Radioisotopes.*

MUNAWAR, M.[1], MUNAWAR, I.F.[2], FITZPATRICK, M.[1], and NIBLOCK, H.[1], [1]Fisheries & Oceans Canada, 867 Lakeshore Road, Burlington, ON, L7R 4A6; [2]Plankton Canada, Burlington, ON. **The Microbial and Phytoplankton Communities of the Laurentian Great Lakes: Ignored, Understudied and Under-Valued.**

The study of phytoplankton of the Great Lakes received very little attention historically as evidenced by the preliminary identifications made in the 1950s-60s. In the 1970s, Fisheries & Oceans Canada (DFO) organized the first comprehensive lakewide surveys of phytoplankton communities. Phycologists with extensive training in taxonomy were assigned the task of producing consistent biomass and species composition data through the use of the Utermöhl inverted microscope technique. Over the years, this structural data has been supplemented by size fractionated primary productivity measurements as well as the microbial loop including bacteria, picoplankton, heterotrophic nanoflagellates and ciliates which has enhanced our understanding of food webs. Unfortunately, most surveys still rely on simple measurements of chlorophyll a as a crude estimate of the algal standing crop which does not reflect the diversity, structure or function of the organisms at the base of the food web. The high level of expertise needed for detailed taxonomic analysis helps to explain this state of affairs. This presentation will highlight the research being carried out by DFO and discuss some of the difficulties in obtaining consistent and reliable species and size composition data for phytoplankton and other microscopic organisms. *Keywords: Algae, Microscopy, Food chains, Taxonomy.*

MUNOZ UCROS, J., REED, A.J., and HICKS, R.E., Department of Biology, University of Minnesota Duluth, Duluth, MN, 55812. **Planktonic Archaeal Diversity and Ammonia Oxidizer Abundance Change with Depth in East African Great Lakes Malawi and Kivu.**

Planktonic *Archaea* may play a key role in the marine nitrogen cycle by oxidizing ammonia, but little is known about them in large lakes of the world. Differences in the abundance of total *Archaea*, marine group I *Archaea* (MG1), and ammonia oxidizing *Archaea* (AOA) were compared during stratified conditions in Lakes Malawi and Kivu, tropical African great lakes. Total *Archaea*, MG1, and AOA abundances increased by more than two orders of magnitude in Lake Malawi from the warm epilimnion to the oxic upper hypolimnion, but remained abundant in the deeper anoxic hypolimnion. While total archaeal abundance also increased with depth in Lake Kivu, MG1 and AOA abundances were lower and did not change substantially. 16S rRNA clones related to the *Thaumarchaeota*, possible ammonia oxidizers, and those from previous work in Lake Victoria were present in both lakes and euryarchaeal clones were common in the deeper anoxic waters. The distribution and diversity of planktonic *Archaea* in these tropical great lakes were similar to Lake Superior, a temperate great lake of comparable trophic status. *Keywords: Microbiological studies, Archaea, Lake Malawi, Nitrogen, Africa.*

MURALIDHARAN, D.[1] and FERNANDEZ, L.M.[2], [1]1400 Townsend Drive, School of Business and Economics, Michigan Technological University, Houghton, MI, 49931; [2]1000 W Cary St., Center for Environmental Studies and School of Business,, Department of Economics, Virginia Commonwealth University, Richmond, VA, 23284. **An Economic Analysis of Binational Water Quality Improvement in the Great Lakes.**

The Great Lakes have undergone binational efforts focused on restoration of water quality and protection of natural resource resilience for over a few decades. Little attention has gone towards the economic aspects of binational management for improving water quality. We seek to fill the gap by offering a focused economic investigation of the time horizon in which the goals of targeted phosphorus reduction were met. We include the relevant role of the International Joint Commission (IJC) in the analysis that compares unilateral versus joint decision-making between the U.S. and Canada. We use a hydrological economic model including the Chapra and Sogzoni segmented state equation and pollution reduction cost information for the bi-national setting surrounding the western basin of Lake Erie. In this area, there is a combination of the urban point sources for abatement by both countries as well as diffuse runoff in rural settings. The goal is cost minimization subject to the constraint imposed on Phosphorus (P) loading. This constraint is obtained from mass balance modeling by Chapra and Dolan. Further, we look at the role the IJC plays in establishing such quality constraints and include in the analysis the relevant costs to the governments of the U.S. and Canada in terms of their contributions to the IJC. *Keywords: Environmental effects, International Joint Commission, Economic evaluation, Lake Erie.*

MURPHY, C.A.[1], SMITH, S.E.[1], GOETZ, F.W.[2], and SITAR, S.[3], [1]Department of Fisheries and Wildlife, Michigan State University, East Lansing, MI, 48824; [2]NOAA Manchester Research Station, 7305 E. Beach Dr., Port Orchard, WA, 98366; [3]Marquette Fisheries Research Station, Michigan Department of Natural Resources, Marquette, MI, 49855. **The Influence of Life History on Sublethal Response to Sea Lamprey Parasitsm in Lake Trout: Population Level Implications.**

Sea lamprey will often kill their lake trout hosts, but survivors may be left physiologically impaired. Current lake trout population models do not incorporate the likely decrease in growth and reproductive ability in a survivor due to a sea lamprey attack and may be underestimating the full effects on lake trout populations. Our study aims to quantify the sublethal effects of parasitism and to compare between morphotypes. We examined the effects of an attack on the lean and siscowet morphotypes. Both morphotypes were subjected to sea lamprey parasitism and analyzed for various physiological metrics and hepatic gene expression. Field collections from Lake Superior were also collected and sampled to determine the range of responses experienced in the wild. Results showed that lake trout exhibit sublethal responses to parasitism and that endocrine, immune and bioenergetics systems are affected. Furthermore, siscowets and leans respond differently to sea lamprey parasitism; siscowets mount an immune response and sacrifice lipid storage to combat parasitism, where leans show an overt stress response and express genes related to circulatory compensation and bioenergetics. Both leans and siscowets show evidence of endocrine disruption. These sublethal effects can translate to

differential population impacts for each morphotype. *Keywords: Endocrine disruption, Lake trout, Lake Superior.*

MURPHY, E.W.[1], BLUME, L.J.[1], SCHOFIELD, J.A.[2], MILLER, K.M.[2], MASRI, S.F.[2], LANDON, M.E.[2], and KLONICKI, P.T.[3], [1]U.S. EPA Great Lakes National Program Office, 77 West Jackson Boulevard, Chicago, IL, 60622; [2]CSC, 6361 Walker Lane Suite 300, Alexandria, VA, 22310; [3]CSC, 8044 Montgomery Road Suite 700, Cincinnati, OH, 45236. **40 Years of Fish: Consolidating and Reconciling Data from a Longitudinal Study.**

The U.S. EPA GLNPO's Great Lakes Fish Monitoring and Surveillance Program (GLFMSP) focuses on monitoring trends in contaminant concentrations in fish collected in the Great Lakes' open waters using top predator fish as biomonitors for select contaminants. GLNPO recently developed a customized database for the GLFMSP specifically based on the past and current nature of the program. This database provides meaningful and straightforward querying of 40+ years of data that have been collected for a program which has included different agencies, collaborators, study designs, and laboratories across the duration of the program. During development, GLNPO revisited historic data collected from 1970-1998 and conducted a series of systematic checks between data sources to identify and resolve any data inconsistencies to ensure comparable and accurate data across the history of the program. Results of investigations also will be reflected in GLNPO's publicly available Great Lakes Environmental Database (GLENDA). We will discuss overcoming the challenges of dealing with 40+ years of data and compiling it into a single, user-friendly database. *Keywords: Fish, Longitudinal study, Data storage and retrieval, Data quality.*

MUSIC, B., FRIGON, A., and SLIVITZKY, M., Ouranos-Consortium on regional climatology and adaptation to climate change, 550, Sherbrooke W, Montreal, QC, H3A 1B9. **Great Lakes Hydrology Under Present and Future Climate Conditions as Simulated by Regional Climate Models.**

Due to the complex interactions taking place at the land-atmosphere and lake-atmosphere interfaces, modeling and projections of historical and future hydroclimatic conditions for the Great Lakes region is not an easy task. Accounting for energy and water exchange between the lake/land and the atmospheric components is crucial to improve the reliability of projected changes in the Great Lakes water levels, needed for water management planning. Taking into account these exchanges requires an interactive coupling of a high-resolution climate model with an appropriate lake model. In most of the available regional climate simulations over North America, the surface conditions over the Great Lakes are questionable. This issue will be addressed in the first part of the presentation through the evaluation of Regional Climate Model simulations belonging to the NARCCAP project, and from an ensemble of CRCM4 simulations generated at Ouranos. Simulated seasonal means and extremes of relevant hydroclimatic variables over the lakes and associated drainage basins will be compared to observations. Projected changes will also be discussed. Finally, a collaborative effort within the MEOPAR project aiming at developing an interactive coupled model (Canadian RCM with NEMO ocean

model) that can be applied to the Great Lakes will be presented. *Keywords: Atmosphere-lake interaction, Climate change, Water level.*

MYCHEK-LONDER, J.G.[1], BUNNELL, D.B.[1], STOTT, W.[1], and DIANA, J.S.[2], [1]USGS Great Lakes Science Center, 1451 Green Rd, Ann Arbor, MI, 48105; [2]University of Michigan, School Of Natural Resources, 440 Church Street, Dana Building, Ann Arbor, MI, 48109. **Slimy (Cottus cognatus) and deepwater sculpin (Myoxocephalus thompsonii) predation on bloater eggs—is it sufficient to drive bloater recruitment variability in Lake Michigan?**

Bloater (Coregonus hoyi), a commercially fished deepwater cisco in Lake Michigan, is at record low levels of abundance. We tested a pattern that indicated bloater recruitment from 1973-2008 was regulated by slimy sculpin (Cottus cognatus) preying on bloater eggs. To that end, we estimated benthivore diets February-May 2009-2010, at four offshore Lake Michigan sites and used genetic techniques to reveal mean bloater egg proportions by dy weight in sculpin diets = 0.02-0.04. To estimate consumption, we determined lab-based sculpin gastric evacuation rates and a sculpin index of stomach fullness [(g prey/g fish weight)100%]. We calculated daily consumption = 0.2-0.8% of sculpin body weight. At the population level, sculpin consumed > 25% of total bloater egg production from 1975-1980 and 2008-2010. We only partially supported the hypothesis that egg predation regulates recruitment. We could not explain poor bloater recruitment during 1995-2005 but suggest that high densities of slimy sculpin in 2008-2010 may be depressing a bloater recovery. Our research exemplifies potential ecosystem based fisheries management approaches given that lake trout (Salvelinus namayacush) predation controls slimy sculpin abundance. Future research is needed to understand bloater recruitment in Lake Michigan and aid bloater restoration in Lake Ontario. *Keywords: Lake Michigan, Sculpin, Fisheries, Consumption, Fish management, Coregonus.*

NDINGA MUNIANIA, C., CLEVINGER, C.C., and BADE, D.L., Kent State University, Kent, OH, 44240. **Response of Nitrification to Ammonium Additions and its Relation to Oxygen Consumption in Lake Erie.**

The role of nitrification as an oxygen consumptive process and its contribution to hypoxia has received limited attention in freshwater environments. Nitrification in Lake Erie contributes around 30 ± 20% (mean ± 1 S.D.) of the total oxygen demand. This process alone has the potential to deplete the mass of oxygen in the hypolimnion. We examined how nitrification responds to ammonium additions and how this influences oxygen consumption. Short term pulse additions of ammonium resulted in minimal stimulation of nitrification. However, long term additions of ammonium (over the course of a week) caused an increase in nitrification rates. Ammonium additions also sometimes caused the percentage of oxygen consumption due to nitrification to increase. From these experiments, the low half-saturation constants suggest that nitrifying bacteria are probably operating near their maximum capacity in Lake Erie, despite relatively low concentrations of ammonium in the lake. Since the nitrifying bacteria are not physiologically capable of increasing their nitrification rate, any large increases must come from increases in abundance. From laboratory cultures we show that increased nitrifier abundance can

influence nitrification rates, however detecting this relationship with samples from Lake Erie has been difficult. *Keywords: Nitrification, Nutrients, Anoxia.*

NEESON, T.M.[1], MCINTYRE, P.B.[1], JANUCHOWSKI-HARTLEY, S.R.[1], DIEBEL, M.W.[2], DORAN, P.J.[3], and O'HANLEY, J.R.[4], [1]Center for Limnology, University of Wisconsin, Madison, WI; [2]Wisconsin Dept. of Natural Resources, Madison, WI; [3]The Nature Conservancy, Lansing, MI; [4]Kent Business School, University of Kent, Canterbury, UK. **Prioritizing in-stream barrier removal in Great Lakes tributaries.**

Many anadromous fishes have limited access to historical riverine spawning grounds, which are often upstream of barriers (dams, road-stream crossings). The removal or modification of in-stream barriers can restore migratory pathways for these species, but the costs and benefits differ among potential mitigation projects. The restoration community lacks a method for comparing these costs and benefits to assess which barrier removal projects would offer the greatest return on investment. To address this problem within the Great Lakes Basin, we are undertaking a three-phase project with the goal of providing a decision support tool for prioritizing barriers for repair and removal. First, we developed the most comprehensive spatial database of dams (n=7,091) and road-stream crossings (n=268,818) in the Great Lakes Basin. Second, we created a statistical model to estimate barrier passability for different fish guilds. Third, we developed mathematical optimization models to prioritize barriers for repair/removal on the basis of upstream breeding habitat. We will discuss key factors that drive barrier prioritization, future data needs, and the strengths and limitations of an optimization-based approach to river restoration planning. *Keywords: Dam, Migrations, Connectivity, Conservation, Planning, Barrier.*

NELSON, D.[1], ELMER, H.L.[2], ROBINSON, P.[3], and KAHL, K.J.[4], [1]University of Michigan, 440 Church St., 3575 Dana Bldg., Ann Arbor, MI, 48109-1041; [2]Old Woman Creek National Estuarine Research Reserve, 2514 Cleveland Road East, Huron, OH, 44839; [3]University of Wisconsin Extension, 2420 Nicolet Drive, Green Bay, WI, 54311-7001; [4]The Nature Conservancy - Great Lakes Project, 101 E. Grand River Ave., Lansing, MI, 48906. **Great Lakes Climate Needs and User-Focused Adaptation Programs.**

Old Woman Creek and Lake Superior National Estuarine Research Reserves (NERRs) coordinated a collaborative project to assess the climate training and information needs of Great Lakes coastal community planners, stormwater managers, and natural resource managers in order to design and deliver user-focused adaptation training. Hundreds of Great Lakes coastal community professionals and decision-makers participated in interviews, focus groups, and an online survey designed to assess regional climate awareness, attitudes, and information needs. Great Lakes NERRs used the results of this assessment in collaboration with dozens of partners to plan a series of three climate adaptation workshop that engaged over 240 individuals. Regional planning teams customized workshop content and pre- and post- workshop surveys were administered to determine effectiveness. A 10-month follow-up web survey measured whether workshop participants had followed through on intended adaptation progress and

additional phone interviews by The Nature Conservancy drilled even deeper to learn what factors may have enabled or hindered progress through the adaptation process. This poster will highlight key assessment findings as well as outcomes and lessons learned from the training workshops. *Keywords: Education, Adaptation, Climate change, Planning.*

NELSON, H.[1], KAYFETZ, K.[2], and WENCZEL, A.A.[3], [1]Fluid Imaging Technologies, 65 Forest Falls Drive, Yarmouth, ME, 04096; [2]Romberg Tiburon Center for Environmental Studies, San Francisco State University, Tiburon, CA, 94920; [3]Haskin Shellfish Research Laboratory, Rutgers University, Port Norris, NJ, 08349. **A Look at a Method for Automated Plankton Analysis.**

The ability to monitor plankton in freshwater and marine systems is a requirement for understanding the important role these primary producers play in the aquatic food web. The emergence of new automated detection and monitoring tools are helping to foster this understanding, as these tools have the potential to reduce labor intensive manual methods (such as microscopy) or when information is needed quickly in monitoring programs and in remote locations. Determining plankton abundance, biovolume estimates, size classification and taxonomic identification is important when identifying plankton or potentially harmful species in an aquatic system. Here we present data from two studies that demonstrate a method for automated plankton analysis using the continuous imaging particle analyzer FlowCAM. One study examined the interaction of three bivalves to determine what impact augmenting the population of a single species might have on food availability for the bivalve community. A second study compared clearance rates of two co-occurring copepod species on different types and sizes of phytoplankton prey. A review of the methods used and data for the two studies will be presented. *Keywords: Trophic level, Automated Identification, Plankton, Monitoring.*

NETTESHEIM, T.G.[1], VENIER, M.[2], SALAMOVA, A.[2], and HITES, R.A.[2], [1]USEPA Great Lakes National Program Office, 77 W. Jackson Blvd, G-17J, Chicago, IL, 60604; [2]Indiana University, 702 N. Walnut Grove Ave., Bloomington, IN, 47405. **Are emission reduction strategies working? An assessment of PAHs data from the Integrated Atmospheric Deposition Network.**

Polycyclic aromatic hydrocarbons (PAHs) are persistent toxic substances that have been the subject of emissions reduction strategies for well over two decades. These strategies range from regulatory programs under the Clean Air Act (e.g. Maximum Allowable Control Technology (MACT) standards and mobile sources emission reduction programs) to voluntary programs under the Great Lakes Binational Toxics Strategy. Air and precipitation data will be presented from the Integrated Atmospheric Deposition Network (IADN) to illustrate spatio- and temporal trends of PAHs from five stations in the U.S. The data will also be compared to trends in emissions of PAHs as determined by inventories collected by the Great Lakes States and USEPA. *Keywords: Assessments, Atmospheric circulation, PAHs.*

NEUREUTHER, N.[1], JOHNSON, E.A.[2], KIMBROUGH, K.[2], JACOB, A.[2], and KLAPER, R.D.[1], [1]School of Freshwater Sciences, University of Wisconsin-Milwaukee, 600 East Greenfield Ave., Milwaukee, WI, 53217; [2]NOAA's Mussel Watch Program, 1305 East West Highway, SSMC4, Room 9202, Silver Spring, MD, 20910. **Determining the impacts of toxics in the Great Lakes using genomic biomarkers of mussels involved in the contaminant monitoring of the NOAA Mussel Watch Program.**

In this project we examined genomic biomarkers related to stress, reproduction, and general physiology in dreissenid mussels in locations known to be heavily contaminated, sites that had been remediated, and those that had been determined to be less contaminated in the Great Lakes. This was in conjunction with NOAA's NCCOS Mussel Watch Program, which monitors chemical pollution of nearly 150 contaminants in the nearshore zones of the Great Lakes. Under the Great Lakes Restoration Initiative this has included Areas of Concern (AOC) around the Great Lakes. Our research builds on the chemical presence information by adding information on the health of mussels within these Areas of Concern versus other long-term reference sites. This includes a multi-agency project in the Manistique AOC to identify and distinguish the sources of PCBs contributing to high concentrations in localized areas of the AOC. Quantitative PCR was used to measure candidate biomarkers above in relation to level and type of contamination. In addition, next-generation sequencing was used to identify new biomarkers that indicate the physiological state of these organisms. Our data indicate a distinct gradient for mussels from "clean" versus contaminated sites where PCB's in particular cause significant changes in cytochrome P450 biomarkers. *Keywords: Biomonitoring, Environmental effects, Environmental contaminants.*

NEVERS, M.B.[1], ROCKWELL, D.[2], CAMPBELL, K.[2], BREITENBACH, C.[3], and WHITMAN, R.L.[1], [1]U.S. Geological Survey, 1100 North Mineral Springs Road, Porter, IN, 46304; [2]CILER University of Michigan and NOAA Center of Excellence for Great Lakes and Human Health, Great, 4840 South State Road, Ann Arbor, MI, 48108; [3]Chicago Park District, 541 N. Fairbanks, Chicago, IL, 60611. **Evaluation of 2011-2012 Beach Water Quality Management Decision Support Systems for Five Chicago Beaches.**

Beaches in Chicago have been the focus of new methods and technology to provide swimmers with more accurate recreational water quality information. Historically, the beaches have been monitored for *E. coli*, an indicator of fecal contamination, but long analytical time undermines the method's effectiveness. In 2011, beaches were equipped with buoys and weather stations for developing real-time predictive models (swimcast). In 2013, NOAA-NWS Forecast office will be operationally testing an experimental water forecasting system for five beaches. We evaluate the accuracy, sensitivity (high bacteria correctly predicted as unsafe for swimming), and specificity (low bacteria correctly predicted as safe for swimming) for four beach monitoring strategies: (1) true value, (2) monitoring for culturable *E. coli*, (3) swimcast, and (4) NOAA forecast. Comparison of potential health risk and economic impact of the management tools will be presented. The five beaches selected have 100 or more *E. coli* samples, are adjacent to Lake Michigan with varying hydrodynamic interaction with the lake, have two years of USGS swimcast data available, no known point source impacts, and ≥5% of the water samples

exceeding the single-sample regulatory standard. Results for 2012, with low precipitation, will be discussed. *Keywords: Water quality, Human health, Lake Michigan.*

NEWSTED, J.L.[2], HOLEM, R.[1], and TEZELAAR, D.[1], [1]Cardno Entrix, 4295 Okemos Road, Suite 101, Okemos, MI, 48840; [2]Department of Animal Science, Michigan State Univeristy, East Lansing, MI, 48824. **A toxicological assessment of perfluorooctane sulfonate (PFOS) to avian wildlife in North America: A spatial and temporal evaluation.**

Perfluorochemicals (PFCs) including perfluoroalkyl sulfonates (PFSA), perfluorocarboxylates (PFCA) and fluorotelomers have been measured in tissues of wildlife species in many parts of the world including the Laurentian Great Lakes. To date the predominant PFC measured in most wildlife species has been perfluorooctane sulfonate (PFOS). While most studies conducted have focused on the spatial and temporal distribution of PFCs in in the environment few have evaluated the toxicological significance to biota. To address this information gap a risk evluation was conducted with birds. Avian tissue-based toxicity reference values (TRVs) for PFOS were derived using existing in vivo and in ovo studies conducted with several avian species including. PFOS concentrations in tissues of birds from different North American eco-regions and trophic levels were determined and compared to blood, liver and egg-specific TRVs. In nearly all cases current concentrations of PFOS are less than the avian toxicity thresholds values including those observed in the Great Lakes. However, given that multiple PFCs have been measured in birds, we will also discuss potential approaches to conducting hazard assessment of PFC mixtures based on current toxicological data and identify data gaps that need to be addressed to better estimate these risks *Keywords: Environmental contaminants, Perfluorooctane sulfonate, Risk assessment.*

NEWTON, R.J., BOOTSMA, M.J., DETUNCQ, I.C., and MCLELLAN, S.L., 600 E. Greenfield Ave., School of Freshwater Sciences, Milwaukee, WI, 53204. **The Bacterial Footprint of a City: Views from Lake Michigan Surface Waters.**

The aquatic bacterial community composition of the Great Lakes is relatively unknown. To further our understanding of these communities, we used 16S rRNA gene sequencing to examine bacterial community structure within Lake Michigan surface waters surrounding the main harbor of Milwaukee, WI. Lake Michigan waters were largely composed of cosmopolitan freshwater bacteria such as acI, *Limnohabitans*, LD12, and *Algoriphagus*. We compared the composition of the lake communities to the composition of several input communities originating from the urban environment including: sewage, urban rivers, stormwater, and animal fecal samples. From these comparisons, we made source inferences for each taxon present in the Lake Michigan communities. During dry weather periods, the bacterial community composition was mainly comprised of taxa typically associated with freshwater lakes. In contrast, following rain events, "urban-associated" bacteria were regularly recovered in samples collected up to 8 km from shore. Quantification using qPCR for two abundant "urban-associated" bacterial taxa (*Arcobacter* and *Acinetobacter*), suggested the footprint of bacteria stemming from the urban

environment is consistently present in surface water sites within 2 km of the harbor mouth. *Keywords: Coastal ecosystems, Bacteria, Lake Michigan, Species composition.*

NGUYEN, T.D.[1], THUPAKI, P.[1], ANDERSON, E.J.[2], and PHANIKUMAR, M.S.[1], [1]Department of Civil & Environmental Engineering, Michigan State University, East Lansing, MI, 48823; [2]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 48108. **Mean summer circulation in Saginaw Bay and Lake Huron: Results from a high resolution unstructured grid numerical model.**

We present results of circulation in Saginaw Bay and Lake Huron during summer months (July-September) for three consecutive years - 2009, 2010, and 2011. Lake-wide as well as near-shore processes were resolved using an unstructured grid, finite-volume hydrostatic ocean model (FVCOM). The model results are tested against ADCP measurements of current profiles in the Saginaw and Hammond Bays. Results from the numerical model are used to perform a statistical analysis of inter- and intra-seasonal variability in circulation. Mean circulation is predominantly cyclonic in the main basin of Lake Huron during the summer months with current speeds in the surface layer being highest in July. Based on the horizontal and vertical velocity profiles, the mass exchange rate between Saginaw Bay and the main body of Lake Huron is estimated. The evolution of thermal structure and its impact on circulation in Saginaw Bay and Lake Huron is also examined in this study. *Keywords: Lake Huron, Saginaw Bay, Hydrodynamics.*

NOMAN, S.[1], MOYERBRAILEAN, G.A.[1], GIZICKI, J.P.[1], RAM, M.L.[1], FUJIMOTO, M.[1], GREEN, P.A.[2], and RAM, J.L.[1], [1]Wayne State University, Detroit, MI, 48201; [2]National Park Service, Isle Royale National Park, Houghton, MI, 49931-1896. **Effects of an Alkaline Ballast Water Treatment on Ballast Water Bacterial Populations.**

Microorganisms transported in ship's ballast may harm the Great Lakes. The efficacy of ballast water treatment (BWT) in eliminating live organisms was determined using propidium monoazide (PMA) PCR to differentiate between live and dead bacteria. Ballast water from a Great Lakes ship was collected from the intake and discharge of both control and pH 12 (2 days followed by neutralization) treated tanks. 16S rRNA gene pyrosequencing (>1,400,000 reads for 16 bar-coded samples) revealed that the microbial communities were altered by the alkaline treatment. Treated water was dominated by genus *Alishewanella* spp. which accounted for <0.2% of the total reads in intake samples but >25% of the reads in the treated discharge. Rarefaction analysis of the pyrosequencing data suggests that alkaline BWT decreased diversity. Quantitative PCR with universal primers targeting 16S rRNA gene showed similar amounts of bacterial DNA in all intake samples but 69-fold and 16-fold increases in total and PMA-resistant bacterial DNA, respectively, in the treated water relative to the control. The increased DNA may be due to growth of alkaline resistant *Alishewanella* during or after treatment and/or detachment of existing biofilm. This study showed the effect of an alkaline BWT, but concerns remain with regard to resistant strains. *Keywords: Biological invasions, Microbiological studies, Ballast.*

NOTARO, M.[1], ZARRIN, A.[2], VAVRUS, S.[1], and BENNINGTON, V.[1], [1]Center for Climatic Research, University of Wisconsin-Madison, 1225 West Dayton Street, Madison, WI, 53706; [2]Department of Geography, Ferdowsi University of Mashhad, Mashhad, Iran. **Simulation of heavy lake-effect snowstorms across the Great Lakes Basin by RegCM4.**

A historical simulation (1976-2002) of the Abdus Salam International Centre for Theoretical Physics Regional Climate Model Version 4, coupled to a one-dimensional lake model, is validated against observed lake ice cover and snowfall across the Great Lakes Basin. The model reproduces the broad temporal and spatial features of both variables in terms of spatial distribution, seasonal cycle, and interannual variability, including climatological characteristics of lake-effect snowfall, although the simulated ice cover is overly extensive largely due to the absence of lake circulations. A definition is introduced for identifying heavy lake-effect snowstorms in regional climate model output for all grid cells in the Great Lakes Basin, using criteria based on location, wind direction, lake ice cover, and snowfall. Simulated heavy lake-effect snowstorms occur most frequently downwind of the Great Lakes, particularly to the east of Lake Ontario and to the east and south of Lake Superior, and are most frequent in December-January. The mechanism for these events is attributed to an anticyclone over the central U.S. and related cold air outbreak for areas downwind of Lakes Ontario and Erie, in contrast to a nearby cyclone over the Great Lakes Basin and associated cold front for areas downwind of Lakes Superior, Huron, and Michigan. *Keywords: Great Lakes basin, Climate change, Atmosphere-lake interaction.*

NOVITSKI, L.[1], STEVENSON, R.J.[1], ESSELMAN, P.[1], and QI, J.[2], [1]203 Natural Sciences Building, Michigan State University, East Lansing, MI, 48824; [2]206 Geography Building, Michigan State University, East Lansing, MI, 48824. **Using MODIS and Landsat to Infer Chlorophyll in Great Lakes Surface Waters with a Focus on Saginaw Bay.**

Remote sensing can provide spatially and temporally extensive characterizations of chlorophyll a (chl) in surface waters. We plan to relate these characterizations of algal biomass to nutrient loading from watersheds to refine our understanding of algal-nutrient-land use relationships. In this paper, we describe the development of models that predict chl with bands and band ratios from satellite imagery. Water quality parameters from 2007-2009 were obtained from the Great Lakes National Program Office and used with pixel values from Landsat and MODIS images to create and test statistical models that predict chl for the Great Lakes. Boosted regression tree (MODIS: 0.10 RMSE, 0.85 R^2; Landsat: 0.61 RMSE, 0.74 R^2) models outperformed linear regression or classification and regression tree models. In general, the MODIS model predicted higher chl concentrations in August than in July as well as along shore of Saginaw Bay and the Saginaw River mouth. Landsat model predictions showed similar chl trends to the MODIS. Model differences included the MODIS model providing a greater range of chl outputs, and Landsat providing finer spatial resolution. Chl predicted by models should be useful in relationships with nutrient loading from nearby rivers to refine our understanding of factors regulating algal bloom risks. *Keywords: Phytoplankton, Remote sensing, Model testing.*

O’BRIEN, T.P.[1], IRELAND, S.[1], ROSEMAN, E.F.[1], BRIGGS, A.S.[3], and TAYLOR, W.W.[2], [1]U.S. Geological Survey Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105; [2]Michigan State University Department of Fisheries and Wildlife, 13 Natural Resources, East Lansing, MI, 48824; [3]Central Michigan University, Department of Biology, Brooks Hall 217, Mt. Pleasant, MI, 48859. **Abundance, distribution, and diversity of pelagic icthyolplankton in a northern Lake Huron embayment.**

Examining spatial and temporal variation in ichthyoplankton assemblages advances our understanding of early life history dynamics often revealing factors important in structuring patterns in distribution and abundance. We sampled pelagic ichthyoplankton in St. Martin Bay, Lake Huron from May-August during 2008-09 to measure variation in abundance and diversity of larval fishes across temporal, thermal, and depth gradients. Larval fish density and diversity was highest at shallow sites (2.5m) and generally decreased with increasing depth (5-10m). Diversity was highest during June and July and when water temperatures reached 15-20C. Density was highest during late July and August, primarily driven by abundance of non-native species. Mean densities were higher during 2008, but diversity was generally higher during 2009. Ichthyoplankton assemblages were dominated numerically by non-native species (rainbow smelt, round goby, alewife) during both years of this study. Rainbow smelt occupied the longest temporal period of any species and overlapped with most larval fish species in space and time. These results emphasize the importance of coastal embayments as nursery habitats for fish and provide insight on the degree of spatial and temporal overlap between native and non-native fishes during critical early life history stages. *Keywords: Lake Huron, Larval fish, Species composition, Fish populations.*

O’MALLEY, A.L., Department of Psychology, 4600 Sunset Ave., Indianapolis, IN, 46208. **Positive Psychological Perspectives on Water Conservation Behavior.**

There is no shortage of strategies grounded in psychological science that are intended to promote conservation behavior. For instance, it is now best practice to appeal to positive social norms, as when signs in hotel bathrooms inform guests that the majority of fellow guests reused their towels. Unfortunately, however, few strategies inspire reliable, enduring patterns of behavior change, an outcome that leaves many social scientists and laypeople alike discouraged and prone to expressing pessimistic views about humans (e.g., humans are present-focused, self-centered consumers with little regard for waste). In an effort to counter such portrayals of humans as fallible information processors who must be manipulated and incentivized to correct dysfunctional behavior, I draw upon positive psychological perspectives to cultivate positive emotional states (e.g. hope, optimism) alongside actual conservation behavior. Incorporating examples from an undergraduate conservation psychology course that encourages students to act as "citizen scientists" and partnerships with grassroots community organizations such as Reconnecting to Our Waterways (ROW), I discuss how emphasizing connections between conservation behavior and well-being can foster citizen engagement and combat perceptions that conservation is an onerous undertaking. *Keywords: Conservation, Water Use, Behavior.*

O'MALLEY, B.P. and BUNNELL, D.B., USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105. **Seasonal Diet of the Opossum Shrimp, *Mysis diluviana*, in Lake Michigan Using Stomach Contents.**

Despite being an important offshore planktivore in the Great Lakes, the seasonal diet of *Mysis diluviana* in Lake Michigan is not well described especially since the recent declines in primary production and changes in zooplankton community composition. In this study we describe the nocturnal diet of *M. diluviana* in Lake Michigan by quantifying stomach contents from specimens collected monthly (April-October) at a 110m depth station. Zooplankton prey could be identified to species or genus from stomach contents using diagnostic body parts (e.g. mandibles). Phytoplankton was also quantified, although some taxa (e.g. *Fragilaria*) were scored based on estimated cell counts. Preliminary results reveal that phytoplankton was observed in stomach contents throughout the sampling period. Common zooplankton prey included the cladoceran genera *Bosmina* and *Daphnia*, and the calanoid genus *Leptodiaptomus*. We also document that immature and adult mysids consumed invasive predatory zooplankton. Larger mysids tend to consume more zooplankton whereas smaller mysids appear to rely more on phytoplankton. The diet results are compared to stable isotope estimates of mysids and other planktivores in Lake Michigan and place *Mysis* planktivory in the larger Lake Michigan food web context. *Keywords: Zooplankton, Mysids, Lake Michigan, Diets.*

OGOREK, J.[1], KRABBENHOFT, D.[1], DEWILD, J.[1], TATE, M.[1], THOMPSON, C.[1], WARREN, G.J.[2], and NETTESHEIM, T.G.[2], [1]U.S. Geological Survey, 8505 Research Way, Middleton, WI, 53562; [2]U.S. Environmental Protection Agency-Great Lakes National Program Office, 77 West Jackson Boulevard, Chicago, IL, 60604. **Mercury and Methylmercury Content of Seston across the Great Lakes.**

As part of the Great Lakes Restoration Initiative, a joint effort by the U.S. Geological Survey and U.S. Environmental Protection Agency was initiated to assess total mercury (HgT) and methylmercury (MeHg) in water, seston, sediment, and benthos in the Great Lakes; the focus of this paper is to describe results from seston sampling. Beginning August, 2010, twice annual (April and August) sampling surveys were conducted. Seston (>63 um) and water were collected from the top 20 m of the water column and analyzed for HgT, MeHg, and dissolved organic carbon (DOC). Initial data show seston MeHg and HgT concentrations (ng/g) ranged 0.49 - 18.1 and 21.6 - 204, respectively. Clear differences for seston MeHg levels were observed between April and August; April MeHg concentrations were 48% to 199% higher than August in all lakes except Erie, which decreased 36% to 44% of August levels. April MeHg concentrations varied considerably (Superior > Huron > Michigan > Ontario > Erie, west basin > Erie) and was inversely related to DOC. Seston-water MeHg fractionation was variable, but appeared to be highest in Superior and lowest in Erie. In August 2012, our sampling included additional size fractioning of seston and flow calibrated plankton tows (to quantify standing masses); analyses are ongoing and will be reported during this presentation. *Keywords: Methylmercury, Seston, Plankton, Mercury.*

OMARA, M., CRIMMINS, B., HOPKE, P., CHANG, F.C., and HOLSEN, T.M., 8 Clarkson Avenue, Clarkson University, Potsdam, NY, 13699. **Assessment of Food Web Structure, Mercury Bioaccumulation and Trophodynamics in Lake Superior.**

In this study, food web structures and total mercury (THg) concentrations in water and biota from a nearshore (AI, Apostle Islands) and an offshore (KP, Keweenaw Point) Lake Superior site were evaluated. Inter-site variability in THg concentrations, δ15N and δ13C signatures, and bioaccumulation and biomagnification factors between water, macroinvertebrates, forage and piscivorous fishes were assessed. Despite very low aqueous THg, assessment of THg trophodynamics indicated that mercury is biomagnifying at both sites at rates similar to those observed in other freshwater lakes globally. The food webs of Salvelinus namaycush were significantly different at the two sites, and concomitant with significant spatial differences in THg burden for this species. THg were not correlated with body weight. Small Salvenilus namaycush siscowet occupied the highest trophic position at both sites, and bioaccumulated THg at levels that approached or exceeded 0.2 µg/g (on a wet weight basis), particularly at the AI site. *Keywords: Biomagnification, Mercury, Stable isotopes.*

ORMISTON, A.K. and MOU, X., Department of Biological Sciences Kent State University, 256 Cunningham Hall, Kent, OH, 44242. **Temporal and spatial variability of microbial community compositions along a transect from the western basin to the central basin of Lake Erie.**

Through close interactions with biotic and abiotic environments, microbial communities in natural lakes mediate numerous biogeochemical processes that are essential in regional and global cycles of C, N and P. However, the relationship between bacterial community compositions and environmental conditions is still unclear. Lake Erie's natural gradient of nutrient supply and many other environmental parameters from the western basin to the central basin provides an ideal experiment to examine how well bacterial community composition tracks environmental changes. Water samples were collected at different depths along a transect that ran from the Sandusky Bay (hypereutrophic) via Western Basin (mesoeutrophic) to the Central Basin (oligotrophic) in June, July and August 2012. Physiochemical parameters were measured in situ. Bacterioplankton was collected on filters and filtrates were used for nutrient analyses, including ammonium, dissolved organic carbon, dissolved nitrogen, nitrate, nitrite and soluble reactive phosphorus. Chlorophyll-α concentration measurements confirmed the expected gradient of primary productivity among sites. DNA extraction and 16S rRNA gene tag pyrosequencing of bacterioplankton is underway for microbial community identification.
Keywords: Lake Erie, Bacterial community compositions, Microbiological studies.

OSGA, J.J.[1], HOLBROOK, C.M.[2], and MOERKE, A.H.[1], [1]School of Biological Sciences, Lake Superior State University, 650 Easterday Ave., Sault Ste. Marie, MI, 49783; [2]Hammond Bay Biological Station, United States Geological Survey, 11188 Ray Road, Millersburg, MI, 49759.
Spatial Distribution of Adult Sea Lamprey in the St. Marys River.

The St. Marys River is one of the largest producers of invasive sea lamprey (Petromyzon marinus) in the Great Lakes. Current trapping methods remove only a small proportion of spawners. Knowledge of adult sea lamprey migration behavior and spatial distribution is needed to trap at unexplored locations. Acoustic telemetry was used to describe spatial distribution and habitat selection of sea lamprey (n = 421) in the upper St. Marys River during summer 2011. Sea lamprey were surgically implanted with acoustic tags, and released. Thirty-four river kilometers (rkm) were systematically searched biweekly with a portable receiver before, during and after the spawning season. Of the 421 tagged lamprey, only 99 (24%) were detected throughout five sampling periods. The number of tagged sea lamprey detected varied among sampling periods and stations (rkm). Density (number/rkm) of tagged sea lamprey increased over time (before spawning=1.65, during=1.76, after=2.59). Before spawning, 80% of lamprey were observed near the rapids. After spawning, lamprey aggregations shifted; 55% were found near the rapids and 45% aggregated further downriver. Overall, lamprey were more abundant in the deeper, faster moving water. Enhanced knowledge of lamprey migration behavior and spatial distribution patterns can be valuable to the management of lamprey. *Keywords: Distribution patterns, Acoustic Telemetry, Invasive species, St. Marys River.*

OSTER, R.J.[1], WIJESINGHE, R.U.[1], DURIS, J.W.[1], FOGARTY, L.R.[1], TUCKER, T.R.[2], and RILEY, S.[2], [1]USGS Michigan Water Science Center, 6520 Mercantile Way, Suite 5, Lansing, MI, 48911; [2]USGS Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105.
Quantitative Assessment of Bacterial Pathogens at Great Lakes Beaches.

Recreational beaches along the Great Lakes have cultural and economic significance and some of these beaches are often closed due to poor water quality resulting from bacterial contamination. Determining the abundance, sources, and persistence of disease-causing (pathogenic) microorganisms may improve our understanding of their risk to human health. Multiple pathogenic bacteria known to cause gastrointestinal disease in humans were targeted in this study. Quantitative PCR (qPCR) assays for *Shigella* (*ipaH* gene), *Salmonella*, *Campylobacter* (*mapA* gene), and *E. coli* (*Stx2* and *eae* genes) were optimized and used for assessing the abundance of these pathogens at Great Lakes beaches. Approximately 300 samples from three environmental matrices including water, sediment, and *Cladophora* were compared at seven beaches sampled from June through August 2012. Beaches were located throughout the Great Lakes including Lakes Michigan, Huron, Erie, and Superior. The detection of each pathogen gene was site specific, and *Cladophora* seems to be a good harbor for some of these microbes. Comparing the physical, chemical, and environmental characteristics of each beach with the resulting qPCR data will provide a better understanding of the factors correlated with their detection *Keywords: Microbiological studies, Cladophora, Water quality.*

OVEISY, A. and YERUBANDI, R., WSTD, National Water Research Institute, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Winter Modelling of Lake Erie (2004-05) using ELCOM.**

The Great Lakes experience periods of partial ice cover, while Lake Ontario could be covered less than %24, Lake Erie might reach upto %90 ice covered. Ice cover inhibits direct wind stress, so that vertical mixing is sustained only by natural convection. Also, the ice formation usually starts in shallow and coastal region that most of the transport happens. In this study we numerically modelled the ice formation in Lake Erie for winter 2004-05 using ELCOM (Estuary and Lake Computer Model). The model initiated from rest using in lake measured temperature profile and forced using interpolated values from nine meteorological stations around Lake Erie. The model skill has been tested against in lake measured temperature profile during winter as well as ice chart from Canadian Ice Services. The model was able to favourably replicate the ice formation processes and the coverage of the ice on Lake Erie. The inverse stratification under ice cover has been captured by the model and spring thermal bar has been recognized. ELCOM can be coupled with Computational Aquatic Ecosystem Dynamics Model (CAEDYM) for biogeochemical and management studies, therefore, this study could be a base toward winter and multi-year Lake Erie simulations. *Keywords: Hydrodynamic model, Ice, Water currents.*

OZERSKY, T.[1], NAKOV, T.[2], SHCHAPOV, K.S.[3], WRIGHT, K.[1], and MOORE, M.V.[1], [1]Wellesley College, Dept. Biological Sciences, 106 Central St., Wellesley, MA, 02481; [2]University of Texas at Austin, 1 University Station A6700, Austin, TX, 78712; [3]Irkutsk State University, Institute of Biology, Lenin St. 3, Irkutsk, 664003, Russian Federation. **Effects of elevated temperature on a keystone copepod in Lake Baikal, Russia: results of experiments and numerical modeling.**

Long-term monitoring of Lake Baikal shows increasing water temperatures, accompanied by decreased densities of the dominant, endemic copepod *Epischura baikalensis* over the past 60 years. To investigate the effect of increasing temperatures on *E. baikalensis*, we conducted laboratory experiments examining survival, reproduction, and susceptibility of *E. baikalensis* to an oomycete parasite at different temperatures. Our results confirm that *E. baikalensis* is a cold-adapted stenotherm, but show that it is able to survive for prolonged periods (>7 days) at temperatures previously considered lethal (> 15°C). However, increased temperatures had negative effects on reproductive potential of *E. baikalensis*. Additionally, mortality rates of *E. baikalensis* from oomycete infection were higher at increased temperatures. We use the results of our experiments and a simple model to examine population-level consequences of increasing epilimnetic temperatures to *E. baikalensis*. Our results suggest potential mechanisms for the observed decline in *E. baikalensis* abundance, and indicate that continued warming may have far-reaching effects on the pelagic ecosystem of Lake Baikal. *Keywords: Zooplankton, Lake Baikal, Climate change, Populations.*

PADILLA, A. and URBAN, R., Dept. of Civil & Environmental Engineering, Michigan Technological University, 1400 Townsend Dr., Houghton, MI, 49931. **Evaluating Methods of Establish Effective Surface Water Quality Guidelines for Copper in Coastal Stream Mouths of the Keweenaw Peninsula.**

During the years of peak copper production, stamp mills in Michigan's Upper Peninsula extracted copper and released the tailings, or stamp sands, into the environment. Studies have shown that trace metals in the sediments affect macroinvertebrate populations, and more recent work has shown that copper continues to be released from stamp sands into surface waters. Because the concentrations of trace metals that are observed to be toxic often differ significantly between the laboratory and the environment, a better method for determining toxic levels of trace metals in the natural environment is desireable in order to establish surface water quality (SWQ) guidelines that protect aquatic life. Using data collected from the mouths of 50 coastal streams in the Keweenaw Peninsula during the spring and summer of 1 field season, we determined which commonly used macroinvertebrate community metrics are most sensitive to changes in copper concentration. We used Threshold Indicator Taxa Analysis (TITAN) to determine the ecological community threshold for copper. Finally, we assessed the method recently used by the Michigan Department of Environmental Quality (MDEQ) to revise the SWQ criterion for copper. A comparison of the three methods is used to show which is more conservative and more protective of aquatic life. *Keywords: Coastal ecosystems, Macroinvertebrates, Water quality.*

PAINE, A.L.[1], RITZENTHALER, A.A.[3], KRAMER, E.L.[3], and GRONEWOLD, A.D.[2], [1]1190 Undergraduate Science Building, 204 Washtenaw Ave., Ann Arbor, MI, 48109-2215; [2]4840 S State St., Ann Arbor, MI, 48108; [3]G110 Dana Building, 440 Church St., Ann Arbor, MI, 48109-1041. **Monitoring & analysis of Escherichia coli in the nearshore waters of Lake St. Clair.**

Fecal indicator bacteria, specifically, Escherichia coli (E. coli), are used by public health professionals to determine water safety for recreational use. Based on guidance from the U.S. Environmental Protection Agency (U.S. EPA), the Michigan Department of Environmental Quality (MI DEQ) determines the maximum E. coli concentration allowable for recreational uses (i.e. swimming). This ongoing research, which is the first bacterial investigation performed at the National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Laboratory, assesses E. coli contamination of the nearshore water in the Clinton River watershed, a U.S. EPA area of federal concern, and Lake St. Clair. The IDEXX Colilert and membrane filtration methods are used to quantify the concentration of E. coli in these samples. The data are then assimilated into the development of hydrologic and hydrodynamic models that illustrate the plume created by the river as it drains into the lake and aid in the identification of variables influencing the E. coli levels. The research aims to improve public health related management decisions through development of an operationalized water quality forecasting system while increasing public understanding of the watershed's behavior to protect a greater quantity of people. *Keywords: Lake St. Clair, Hydrodynamic model, Monitoring.*

PALLADINO, D.[1], JOHENGEN, T.H.[1], RUBERG, S.A.[2], and PURCELL, H.L.[1], [1]CILER, 440 Church St, Ann Arbor, MI, 48109-1041; [2]NOAA-GLERL, 4840 S. State Road, Ann Abor, MI, 48108. **Application of Instrumented Moorings for Continuous Monitoring of Water Quality Conditions and Harmful Algal Blooms in Western Lake Erie 2011-2012.**

Harmful algal blooms (HABs) are of great concern to the scientific community and the public due their potentially significant detrimental impact on ecosystem and human health. Two continuous monitoring instrumented mooring were established at Toledo Harbor Light and Navigation Light #2 in western Lake Erie to examine detailed temporal dynamics of HAB development and related water quality conditions. . The Toledo Harbor Light is often a hot spot for cyanobacterial blooms, in a large part due to the nutrient input from the Maumee River, and is thought to be a source of cells for the rest of the western basin of Lake Erie. Instrumented moorings collected high temporal frequency data for chlorophyll a, phycocyanin, phycoerythrin, CDOM, turbidity, specific conductivity, phosphorus and temperature. Weekly discrete water sample were collected for laboratory analysis of phycocyanin, chlorophyll a, dissolved nutrients and microcystin in order to validate sensor data. The combination of nutrient and cyanobacterial data from these key locations over the course of bloom seasons provide useful data for generating models of bloom development. Future plans are underway to make these data available in real-time in order to provide an early warning system for bloom detection that may impact swimming beaches or drinking water intakes. *Keywords: Lake Erie, Harmful algal blooms, Water quality.*

PANGLE, K.L.[1], HURTADO, P.J.[2], LOU, Y.[2], MARSCHALL, E.A.[2], RUCINSKI, D.K.[3], BELETSKY, D.[4], and LUDSIN, S.A.[2], [1]Central Michigan University, Mount Pleasant, MI, 48859; [2]The Ohio State University, Columbus, OH, 43210; [3]LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108; [4]University of Michigan, Ann Arbor, MI, 48109. **Do Hypoxia- and Temperature-Induced Changes in Habitat Use Affect Fish Abundance and Quality?**

Hypoxia (low dissolved oxygen availability) and water warming are growing water quality problems worldwide and threaten many aquatic ecosystems and the fisheries that they support. Previous research demonstrates that hypoxia can negatively affect short-term foraging success, growth, and availability of predation refugia in small-bodied prey fishes by forcing fish to aggregate in a narrow (1-2m) band of the water column, in the often unfavorably warm waters, just above the hypoxic zone. The individual and net effects of warming and hypoxia on fish populations in the long term, however, are unknown for virtually all fishes, both freshwater and marine. Further, it remains unclear how annual variation in water temperature and dissolved oxygen availability affect fish abundance and health across years. We have developed a data driven mechanistic model to explore how temperature- and hypoxia-induced changes in vertical migration behavior can influence growth and mortality in a fish population, using Lake Erie rainbow smelt (*Osmerus mordax*) as a model species. The results presented here describe how warming and hypoxia negatively influence fish population size (number) and fish quality (weight) via their impact on other factors (e.g., starvation, predation) important in driving rainbow smelt population dynamics. *Keywords: Bioenergetics, Mathematical models, Climate change, Fish populations.*

PARKER, A.D., ROGERS, B., STEWART, J.G., FINNEY, S.T., and SIMMONDS, JR., R.L., U.S. Fish and Wildlife Service, Carterville Fish and Wildlife Conservation Office, 9053 Route 148, Suite A, Marion, IL. **Fish behavior and abundance at the electric dispersal barrier in the Chicago Sanitary and Ship Canal, Illinois, USA.**

A series of electric barriers currently operate in the Chicago Sanitary and Ship Canal (CSSC) with a primary focus on preventing the upstream migration of bighead (*Hypophthalmichthys nobilis*) and silver carp (*H. molitrix*) into Lake Michigan. When our work began in the summer of 2011, Barrier II was operating at 2.0 V/2.54 cm. In November, 2011, barrier operating parameters were changed to 2.3 V/2.54 cm. Experimental work at the barrier consisted of pulling encaged gizzard shad (*Dorosoma cepedianum*) through the barrier and recording their behavior. Three weeks of caged-fish trials took place while barrier operating parameters were at 2.0 V/2.54 cm. Eight of 270 gizzard shad that were moved through the barrier were not incapacitated. After the barrier operating parameters were increased to 2.3 V/2.54 cm, seven additional weeks of caged-fish trials were performed and all fish were incapacitated. In addition, we conducted observational work that involved recording feral fish at 80 different fixed locations throughout the barrier system using a dual-frequency identification sonar (DIDSON). Review of our DIDSON footage revealed a significant accumulation of feral fish below the barrier and the highest numbers of fish in the summer and fall. *Keywords: Lake Michigan, Invasive species, Fish behavior.*

PARNELL, J.J., National Ecological Observatory Network, Boulder, CO, 80301. **Microbial Ecogenomics in the National Ecological Observatory Network.**

Over the past decade, advances in high throughput DNA sequencing and high-performance computing have transformed the field of microbial ecology. These technologies unlock the largely unexplored frontier of microbial life to assess microbial diversity and function in the context of ecosystem dynamics. I will discuss how detailed ecogenomics have addressed some fundamental microbial ecology questions in the Great Salt Lake. I will also provide details of the National Ecological Observatory Network's (NEON) long-term monitoring plan to high-quality ecological data, including the collection of physical, chemical, and biological data at 106 terrestrial and aquatic sites across the United States, including Alaska, Hawaii, and Puerto Rico. Included in the biological data and sample collections are microbial measurements for community structure (16S/ITS and metagenomics) and function (mRNA sequencing). I will also discuss a framework to link genomics data and the ecological data collected by the observatory network. NEON's long-term and continental scale monitoring plans will provide crucial information for exploring the next generation of molecular ecogenomics in microbial communities. *Keywords: Microbiological studies, Biodiversity, Climate change.*

PATERSON, G.[1], RUSH, S.A.[1], JOHNSON, T.B.[2], DROUILLARD, K.G.[1], HAFFNER, G.D.[1], HEBERT, C.E.[3], ARTS, M.T.[4], MCGOLDRICK, D.J.[4], BACKUS, S.M.[4], LANTRY, B.F.[5], LANTRY, J.R.[6], SCHANER, T.[2], and FISK, A.T.[1], [1]Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, N9B 3P4; [2]Ontario Ministry of Natural Resources, Glenora Fisheries Station, Picton, ON, K0K 2T0; [3]Environment Canada, National Wildlife Research Centre, Ottawa, ON, K1A 0H3; [4]Environment Canada, Water Science and Technology Directorate, Burlington, ON, L7R 4A6; [5]United States Geological Survey, Lake Ontario Biological Station, Oswego, NY, 13126-1025; [6]New York State Department of Environmental Conservation, Cape Vincent Fisheries Research Station, Cape Vincent, NY, 13618. **The Nearshore Shunt Hypothesis: A Comparison Between Lake Ontario and Lake Huron Lake Trout.**

The nearshore shunt hypothesis predicts increasing reliance of Great Lakes food webs on carbon production redirected through invasive species dominated littoral pathways. Using a combination of archived and current food web samples collected from Lakes Ontario and Huron between the early 1980's - 2011, this study used the stable isotopes of carbon (δ13C) and nitrogen (δ15N) to determine potential changes in lake trout ecology that are consistent with the nearshore shunt hypothesis. δ13C values for age classes of Lake Ontario lake trout became increasing less negative over time consistent with the reliance of this top predator on carbon resources redirected through nearshore pathways. However, for Lake Huron lake trout, no significant temporal trends were observed for δ13C values determined in these samples. Two source mixing model predictions demonstrated that the > 90% of fish sampled from the 2008 lake Ontario lake trout population were reliant on nearshore redirected carbon. In contrast, mixing model predictions for Lake Huron lake trout indicated that < 50% of fish sampled in 2010 - 2011were dependent on nearshore derived carbon resources. δ15N values for both Lake Ontario and Lake Huron lake trout demonstrated significant temporal declines suggesting substantial changes in the trophic ecology. *Keywords: Stable isotopes, Lake Huron, Lake trout, Lake Ontario.*

PATTERSON, T.A.[1], GRUNDEL, R.[2], DZURISIN, J.D.K.[1], and HELLMANN, J.J.[1], [1]University of Notre Dame, Notre Dame, IN; [2]Lake Michigan Ecological Research Station, U.S. Geological Survey, Porter, IN. **Assessing Effects of Climate Change on the Endangered Karner Blue Butterfly.**

Climate change could partially explain why populations of endangered Karner blue butterflies (Kbb) at Indiana Dunes National Lakeshore(INDU) continue to decline despite extensive restoration efforts. To test the effects of temperature on the demography of Kbb, an experimental colony of Kbb was established and maintained in four temperature treatments: historic daily average temperatures, historic +2, +4, and +6 °C. Demographic parameters for the four groups including development time, mass of larvae, egg production, and number of generations per year were measured. When exposed to even a small amount of warming, Kbb produced more than the two broods typically recorded each year in the wild. This is problematic because additional broods in the wild will generally lack quality food. Warming also induced earlier egg hatching and accelerated caterpillar development and adult emergence. Additional

experiments revealed that individuals are cold tolerant, but may experience heat stress under summer field conditions. Laboratory and field experiments that assess the availability of wild lupine, the caterpillar's sole food source, as the insects hatch indicate phenological mismatching under recent weather conditions with eggs hatching before food is available.
Keywords: Conservation, Life history studies, Climate change.

PAVLOVIC, N.B.[1], LEICHT-YOUNG, S.A.[2], and GRUNDEL, R.[1], [1]U.S. Geological Survey, 1100 N. Mineral Springs Rd., Porter, IN, 46304; [2]University of Rhode Island, 120 Flagg Rd., Kingston, RI, 02881. **The Distribution of Oriental Bittersweet (Celastrus orbiculatus) in Great Lakes National Parks: The Interplay between Habitat and Disturbance.**

The distribution of exotic plants is a result of the interplay between habitat and disturbance. We use a multiscale approach to dissect the roles of habitat and disturbance in contributing to the distribution and abundance of the invasive liana, oriental bittersweet (*Celastrus orbiculatus*) in the landscape. In areas where prescribed burning is a prevalent management tool, managers need to know how fire affects this species. We investigated 1) seedling establishment among habitats, 2) resprouting and carbohydrate reserves of infestations in response to cutting and burning, 3) distribution of this species across a fire managed landscape, and 4) distribution among forest stands around southern Lake Michigan. Seedling germination varied depending on litter treatment and habitat, but establishment was more affected by habitat. Fire reduces the cover of oriental bittersweet, but increases stem density more than cutting. Cutting bittersweet in early July resulted in a 75% reduction in total nonstructural carbohydrates (TNC) compared to dormant season TNC. The landscape presence of oriental bittersweet was negatively influenced by canopy cover, fire frequency and distance from roads and railroads. We discuss the implications of the results in relation to potential invasion of Great Lakes habitats and strategies for control. *Keywords: Disturbance, Invasive species, Vegetation.*

PEACOR, S.D.[1], MILLER, D.R.[1], WINSLOW, K.[1], FRANCOEUR, S.N.[2], and STOW, C.A.[3], [1]Michigan State University, East Lansing, MI; [2]Eastern Michigan University, Ypsilanti, MI; [3]Great Lakes Environmental Research Laboratory, Ann Arbor, MI. **Multiple Sources of Beach Fouling in Saginaw Bay, Lake Huron: Not Just *Cladophora*.**

Heavy shoreline fouling events are a major nuisance in Saginaw Bay, Lake Huron. The detritus responsible for beach fouling, commonly called "muck," is aesthetically offensive, greatly reducing recreational activities and negatively affecting housing values and business activity in the region. As part of the NOAA sponsored Multiple Stressors project, we examined the potential source(s) of beach fouling. Over the course of our investigation, we became increasingly aware that there are multiple sources of organic matter that lead to substantial beach fouling. In this way, the problem is more complicated than in some other Great Lakes areas, which experience shoreline fouling events that show a clearer connection between nutrients, filamentous algae growth (primarily Cladophora), and ensuing beach fouling. We identified four major sources of organic matter that lead to beach fouling events, including (a) benthic algae

growing offshore (primarily at depths 2-4 m), (b) benthic algae growing near drainage ditch outlets into the bay, (c) extensive Microcystis blooms (e.g., HABs), and (d) macrophytes. We discuss our observed spatial and temporal variation regarding these sources as well as the implications of our study for management of the "muck", which would, unfortunately, vary depending on the dominant source. *Keywords: Cladophora, Saginaw Bay, Eutrophication, Beach Fouling.*

PELLER, J.R.[1], BYAPPANAHALLI, M.N.[2], WHITMAN, R.L.[2], SHIVELY, D.[2], SADOWSKY, M.J.[3], and CHUN, C.L.[4], [1]Indiana University Northwest, 3400 Broadway, Gary, IN, 46408; [2]Lake Michigan Ecological Research Station, Porter, IN, 46304; [3]University of Minnesota, 4Department of Soil, Water, and Climate, St. Paul, MN, 55108; [4]University of Minnesota, BioTechnology Institute, St. Paul, MN, 55108. **In vitro aqueous and atmospheric chemistry of Great Lakes decaying/decomposing Cladophora.**

Cladophora accumulates and decomposes along beaches of the Great Lakes, creating potential threats to human and wildlife health. The decaying algae produce a low oxygen environment favoring growth and sustenance of a range of microbial populations, potentially including Clostridium botulinum, the causal agent of bird botulism. In addition to the diverse population of microbes, a dynamic chemical environment is generated, which involves numerous organic and inorganic substances, many of which are odorous, noxious and likely selective to particular microbial populations. The determination of the predominant chemical components associated with the different stages of algal decay was initiated using mesocosm studies. After a few hours of simulated algal mat assemblage, the oxygen levels were largely depleted and acidosis predominated. A three-month study of the predominantly anaerobic decay of Cladophora led to the identification of numerous organic compounds associated with the different stages of the decay using mass spectrometry detection. Inorganic ion concentrations were quantified with ion chromatography methods and showed interesting fluxes. Knowledge of the fundamental chemical composition and microbial milieu of decaying Cladophora mats is critical to understanding its role on human and animal health. *Keywords: Cladophora, Avian botulism, Chemical analysis, Human health.*

PERHAR, G. and ARHONDITSIS, G.B., University of Toronto, 1265 Military Trail, Toronto, ON, M1C 1A4. **Aquatic ecosystem dynamics following oil spill events: A review of the current state of knowledge.**

Petroleum hydrocarbon spills devastate biotic and abiotic components of pelagic environments. Oil in aquatic environments poses a significant threat to aquatic life, as toxic effects cascade across trophic levels affecting phytoplankton and zooplankton assemblages, fish, aquatic birds and mammals, as well as benthic communities. Confounding the impacts on the aquatic food web are the behavioural characteristics of spilled oil, and the dispersants used in clean up efforts. The 3,700 km Great Lakes - St. Lawrence Seaway is a vital commercial transportation route linking the Great Lakes economic hub to the rest of the world. The large number of transit ships using this route annually makes the threat of an oil spill real. We review the literature and present an integrated ecosystems approach, delving into the consequences of oil spills on aquatic food web interactions, highlighting short- and long-term effects on the integrity of ecosystems. We conclude by highlighting the inability of contemporary models to capture ecosystem response to spill events, and emphasize the need for an ecosystem-centric oil spill model for the Great Lakes. *Keywords: Ecosystem health, Ecosystem modeling, Food chains.*

PERRI, K.A. and BOYER, G.L., SUNY-ESF, 121 Forestry Drive, Syracuse, NY, 13210.
Harmful Algal Blooms in Sodus Bay, Lake Ontario; A Comparison of Shoreline Use and Cyanobacterial Abundance.

Sodus Bay is a large shallow embayment located on the southern shore of Lake Ontario. Sodus Bay is also home to a large recreational boating fleet, serviced by nine marinas located around the bay. In the last three years, Sodus Bay has experienced repeated outbreaks of toxic cyanobacteria including *Microcystis* and *Anabaena* species. To evaluate the impact of shoreline use on the presence of these pelagic algal blooms, water samples were collected weekly for nutrient, pigment and toxin analysis from four marina sites, two residential sites and the public beach located in the Village of Sodus Point. The Bay experienced several cyanobacterial blooms in 2011 and 2012. Peak cyanobacterial abundance occurred in September of both years however isolated blooms were often observed early in the season. Peak toxin concentrations for microcystins were higher in 2011 than in 2012. High variability in total microcystins (peak values ranged from 0.3 - 17 µg/L) was observed between the four different marina sites with some marina locations similar to the residential and beach sites. Correlations between these sites and environmental variables will be presented. *Keywords: Harmful algal blooms, Lake Ontario.*

PERRY, C.H.[1], SEILHEIMER, T.S.[2], ZIMMERMAN, P.L.[3], and STUEVE, K.M.[4], [1]USDA, U.S. Forest Service, Northern Research Station, 1992 Folwell Ave., St. Paul, MN, 55108; [2]Wisconsin Sea Grant, UW-Manitowoc, 705 Viebahn St, Manitowoc, WI, 54220; [3]University of Minnesota - Twin Cities, Minneapolis, MN, 55455; [4]Natural Resources Research Institute, University of Minnesota - Duluth, Duluth, MN, 55811. **Landscape Indicators, Forest Disturbance, and Water Quality: Developing Models in Lake Michigan Watersheds.**

The Great Lakes watersheds have an important influence on the water quality of the nearshore environment, therefore, watershed characteristics can be used to predict the conditions in the streams. We used novel landscape information describing the forest cover change, along with forest census data and established land cover data (e.g. agriculture and urban) to predict total phosphorus and turbidity in Lake Michigan streams. We modeled phosphorus as a function of ecoregion, the proportion of forest disturbed during 1984-1999, watershed storage, and the proportion of urban land, and we modeled turbidity as a function of ecoregion, the proportion of forest disturbed during 2000-2009, and the proportion softwood forest. We used these relationships to identify priority areas for restoration in west central and southwest watersheds of the Lake Michigan basin. Our phosphorus model and an existing Great Lakes nutrient model (SPARROW) agreed on identifying watersheds with highest levels of phosphorus. We then used the models to estimate water quality in watersheds without observed instream data to prioritize

those areas for management. Prioritizing watersheds will aid effective management of the Great Lakes watershed and result in efficient use of restoration funds, which will lead to improved nearshore water quality. *Keywords: Water quality, Watersheds, Lake Michigan.*

PETTITT-WADE, H., WELLBAND, K., HEATH, D.D., and FISK, A.T., Great Lakes Institute for Environmetal Research, University of Windsor, 401 Sunset Avenue, Windsor, ON, N9B 3P4.
The Isotopic Niches of Invasive Gobiidae in the Laurentien Great Lakes.

The distribution and abundance of the invasive round goby since establishment in the Great Lakes is vast, particularly when compared to the invasive tubenose goby. A broad diet can provide potential for plasticity to novel diets, and thus a potential mechanism for successful establishment of aquatic invasive species. We tested the hypothesis that round goby (*Neogobius melanostomus*, eight sites) utilise a broader dietary niche than tubenose goby (*Proterorhinus semilunaris*, two sites), and that round goby populations at long established invasion sites utlise a more restricted, specialist isotopic niche than at more recent invasion sites. Dietary and spatial niche was inferred from Standard Ellipse Area (SEA) of $\delta^{13}N$ and $\delta^{13}C$ (IRMS). Dreissenid's provided baseline for comparisons between systems. Visual and DNA analysis of gut contents and body size was used to support conclusions from isotopic niches. Comparable size round and tubenose goby from the same location had distinct isotopic niches with minimal overlap. Round goby had a wider niche than tubenose goby. The importance of broad niche for broad geographic establishment following invasion is highlighted with reference to a trade off between generalist and specialist niche for long term establishment. *Keywords: Niches, Gobiidae, Stable isotopes, Great Lakes.*

PHELPS, Q.E., TRIPP, S.J., HERZOG, D.P., and HRABIK, R.A., 3815 East Jackson Blvd, Jackson, MO, 63755. **Incorporating basic and applied approaches to evaluate the effects of silver carp on native fishes.**

Understanding fish community interactions is a critical component of large river ecology, especially the interactions of nonindigenous fishes on native fauna. The objective of this study was to determine population level interactions between silver carp and native planktivores. We used data collected for the Long Term Resource Monitoring program in the free-flowing stretch of the Mississippi River and its associated floodplain from 1992-2012. We also employed controlled experiments to determine the potential mechanism structuring the relationship between non-native and native planktivores. Our results suggest that non-native planktivore relative abundance has increased while relative abundance of native planktivorous fishes has declined. As a measure of a limiting resource, we also found that silver carp condition has remained fairly consistent while bigmouth buffalo and gizzard shad condition has declined. Correspondingly, the results of our controlled experiments suggest that silver carp may be able to exclude native fishes via exploitative competition. Based on the results of this study, silver carp are likely negatively influencing native planktivorous fishes (e.g., creating a limiting resource via competition).Thus, management efforts should be directed at reducing silver carp biomass to rehabilitate native planktivores. *Keywords: Silver carp, Invasive species.*

PHILLIPS, J.C. and MCKINLEY, G.A., University of Wisconsin-Madison, 1225 W. Dayton Street, Madison, WI, 53706. **Using Expert Judgments to Evaluate the Prospects for Great Lakes CO_2-driven Acidification.**

The pH of the surface ocean is predicted to drop 0.3-0.4 units by 2100 under steady fossil fuel consumption. Our projections for the Great Lakes suggest a similar decline in pH. However, precise carbonate chemistry monitoring and initiatives have not been implemented, leaving the Great Lakes under-studied with respect to acidification from the increasing absorption of atmospheric CO_2. In addition to biogeochemical modeling, integrated with available carbon chemistry data, we interviewed and surveyed Great Lakes scientists. Lacking research on acidification impacts in the Great Lakes, we employed expert elicitation tools to gauge the community's assessment of the importance of CO_2 acidification as a stressor and the potential ecological and organismal impacts. Based on a survey of 80 scientists, the community is mostly uncertain about the organismal and ecosystem effects. However, 87% of respondents indicate that CO_2-driven acidification is likely. Qualitative interviews with a smaller subset reiterated these findings; the discussion also focused on barriers to studying acidification, specific research priorities, and how to establish a robust monitoring and research program. This interdisciplinary assessment is the first consideration of CO_2-driven acidification in the Great Lakes.
Keywords: Acidification, Great Lakes basin, Expert, Carbon, Carbon cycle.

PICHLOVA-PTACNIKOVA, R.[1], VANDERPLOEG, H.A.[2], and CAVALETTO, J.[2], [1]WasserCluster Lunz - Biological Station GmbH, Dr. Carl Kupelwieser Promenade 5, Lunz am See, A-3293, Austria; [2]NOAA GLERL, 4840 S. State Rd., Ann Arbor, MI, 48108-9719.
Implications of Bythotrephes longimanus and Cercopagis pengoi predation impacts on Lake Michigan food webs.

Invasive species have during last decades induced huge impacts on food webs of Lake Michigan. The invertebrate predators *Bythotrephes longimanus* and *Cercopagis pengoi* have likely contributed to changes in densities of several zooplankton species as both species can have under certain conditions significant predation effect on its prey. We found out that their diets overlap and that they are generalists capable to consume a variety of prey species. Higher consumption rates were found for prey with slow swimming and escape responses than for the fast ones. Further, due to its larger body size, *Bythotrephes* can efficiently prey on *Cercopagis* and suppress thus its food competitor directly. This might explain why *Cercopagis* after initial peak in the year 2000, did not get abundant in Lake Michigan in most years after. We will present a comprehensive overview of *Bythotrephes* and *Cercopagis* consumption, selectivity and impact on Lake Michigan food webs. *Keywords: Bythotrephes cederstroemii, Cercopagis pengoi, Predation.*

PIERCE, L.R.[1], WILLEY, J.C.[2], PALSULE, V.P.[1], YEO, J.[2], CRAWFORD, E.L.[2], SHEPHERD, B.S.[3], and STEPIEN, C.A.[1], [1]University of Toledo Lake Erie Center, 6200 Bayshore Road, Oregon, OH, 43616, US; [2]University of Toledo Medical Center, 3100 Arlington Avenue, Toledo, OH, 43614, US; [3]University of Wisconsin at Milwaukee, School of Freshwater Sciences ARS/USDA, 600 East Greenfield Avenue, Milwaukee, WI, 53204. **A New Real-Time PCR Assay with Internal Controls to Accurately Detect and Quantify the Fish Viral Hemorrhagic Septicemia Virus (VHSv).**

Viral Hemorrhagic Septicemia virus (VHSv) infects >80 marine, freshwater, and estuarine fishes across North America and Eurasia, posing extensive risk to aquaculture, baitfish industries, and native fishery stocks. Despite efforts to reduce detection time, cell culture is the only USDA-APHIS approved diagnostic, which can take months to produce results and lacks the sensitivity needed to identify virus in carrier fishes. Recently, a new, highly sensitive diagnostic assay, Standardized Reverse Transcriptase Polymerase Chain Reaction (StaRT-PCR), was developed by us to detect VHSv, which incorporated a unique internal standard for quality control against false negative results. However, that method relied on Agilent equipment, which is less common in diagnostic laboratories. Here, we develop an alternative easy to use assay with 2-color fluorometric (2CF) real-time PCR, having the same superior quality control and 100% true accuracy down to five viral molecules. Results show marked improvement over other RT-PCR and traditional cell culture in yielding no false negatives. Our test shows that infected fish typically have 1 to 1.21x10^6 number of viral molecules. This new assay is superior and user friendly for accurately detecting and quantifying VHSv. *Keywords: Cell culture, Diagnostic assay, Virus.*

PIJANOWSKI, B.C. and KIM, N., Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN, 47906. **Tipping points: science and policy.**

We will present a summary of concepts of tipping points as they have appeared in the ecological and social science literature. Several forms of tipping points will be described as well as issues that relate to their use in decision making. *Keywords: Decision making, Tipping points, Thresholds.*

PILGRIM, E.M.[1], KELLY, J.R.[2], SCHAROLD, J.V.[2], YURISTA, P.M.[2], COTTER, A.M.[2], MARTINSON, J.[1], and DARLING, J.A.[1], [1]U.S. EPA, Ecological Exposure Research Division, Cincinnati, OH, 45268; [2]U.S. EPA, Mid-Continent Ecology Division, Duluth, MN, 55804. **Environmental metagenomics applied to lake bioassessment using sediment and benthos in Lake Huron.**

With recent advances in metagenomics through next-generation DNA sequencing, bulk environmental sampling could be developed to augment current assessments of environmental health and condition based on community biodiversity. Taking advantage of sampling done as part of the National Coastal Condition Assessment, we investigated the use of bulk DNA extraction through bulk DNA sequencing as a means to understand community composition

relative to environmental condition. We compare our metagenomic results to those generated by standard taxonomic identification of the benthos. *Keywords: Biomonitoring, Metagenomics, Environmental health, Environmental barcoding, Lake Huron.*

PINGATORE, J.E., 205 Billings Street, Valparaiso, IN, 46383. **Valparaiso's Water Conservation Plan.**

The State of Indiana's implementation of the Great Lakes St. Lawrence River Basin Water Resources Compact under IC 14-2-15 and proposed amendments to Rule 312 IAC 6.2 identify and develop voluntary conservation and efficiency objectives in the Great Lakes Basin of Indiana, and encourage all Significant Water Withdrawal Facilities (SWWF) to consider and implement conservation measures. On December 14, 2007 a group of men and women came together for the first time as the Valparaiso City Utilities Water Conservation Task Force and formed their individual ideas into a collective Mission Statement. Over the next two years that group would follow the United States Environmental Protection Agency guidelines for developing a comprehensive Water Conservation Plan for the Valparaiso City Utilities. Water conservation planning goals were specified; a water system profile was developed, utilizing water utility data and service area data; water conservation measures were identified; and a two phase water conservation plan was developed. The Utility is an United States Environmental Protection Agency WaterSense Partner and a member of the Alliance for Water Efficiency; and as a member of the American Water Works Association, the Utility continues to promote water conservation tips for its customers. *Keywords: Conservation, Water Use.*

PISKUR, M.S., 20 N. Wacker Drive, Suite 2700, Chicago, IL, 60606. **Assessing Cumulative Water Use Impacts for the Great Lakes-St. Lawrence River Basin.**

An ongoing challenge for water managers is how to measure and manage the cumulative impacts of multiple and ongoing water uses over time and as part of a comprehensive water budget. While work of this kind has been done on some local riverine systems, large-scale systems like the Great Lakes--St. Lawrence River Basin represent a new and different challenge. In 2013, the Great Lakes Governors and Premiers are conducting the first ever assessment of cumulative water use impacts for the Basin. This groundbreaking effort is being undertaken pursuant to the Great Lakes--St. Lawrence River Basin Sustainable Water Resources Agreement and the companion "Great Lakes Compact." The assessment is the first ever performed on a scale of this magnitude anywhere in the world and is employing new and innovative approaches. This presentation will discuss the unique partnership that is being used for the assessment including how data and information challenges are being tackled. "Lessons learned" will be presented that may be instructive for future work in the region and in other parts of the world.
Keywords: Assessments, Impacts, Decision making, Great Lakes basin.

POGHOSYAN, A.[1], STURCHIO, N.C.[1], JACKSON, W.A.[2], GUAN, Y.[3], EILER, J.M.[3], and HATZINGER, P.B.[4], [1]University of Illinois at Chicago, Chicago, IL; [2]Texas Tech University, Lubbock, TX; [3]California Institute of Technology, Pasadena, CA; [4]Shaw Environmental Inc., Lawrenceville, NJ. **Perchlorate in the Great Lakes: distribution, isotopic composition and origin.**

Concentrations, stable isotopic compositions and 36Cl abundances of ClO4- were investigated in the five Great Lakes. Samples were collected during 2007-2009 on the U.S. EPA's RV Lake Guardian and in 2010 at the water supply intake of Marquette, MI. IC/MS/MS concentrations of ClO4- vary from 0.05 to 0.12 µg/L. δ37Cl and δ18O analyses were performed at Caltech using the Cameca 7f-GEO SIMS. Results indicate a narrow range in δ37Cl values (+2.9 to +4.0‰) and a wider range in δ18O values (-4.7 to +4.1‰). Δ17O was measured at UIC using dual-inlet IRMS of O2. Great Lakes ClO4- has mass-independent oxygen isotopic variations with Δ17O values (+1.6 to +2.5‰) divided into two distinct groups: Lake Superior (~+2.5‰) and the other four lakes (~+1.6‰). The isotopic data indicate that ClO4- is dominantly of natural origin, having stable isotopic composition resembling that of ClO4- from pre-industrial groundwaters in the western USA. The 36Cl/Cl ratios decrease from Lake Superior (66,500E-15) to Lake Ontario (7,400E-15). The high 36Cl/Cl ratios in the lakes having longer water residence times may be explained by retention of the 36Cl bomb pulse. Substantial lost of ClO4- may occur in Lake Erie. 36Cl/Cl results confirm that ClO4- in the Great Lakes has dominantly natural origin.

POWERS, S.M.[1], ROBERTSON, D.M.[2], and TANK, J.L.[1], [1]1400 E. Angela Blvd, South Bend, IN, 46617; [2]USGS Wisconsin Water Science Center, 8505 Research Way, Middleton, WI, 53562. **Landscape differences in the temporal variability of stream nitrogen and phosphorus input to the Great Lakes.**

Transport of phosphorus and nitrogen pollution to the Great Lakes can vary substantially between years and seasons. Temporal variability of pollution input is driven largely by precipitation variability, but also landscape characteristics that influence river responses to precipitation. We used 20 year records of annual nutrient yield (Y), water yield (Q), and mean flow-weighted annual concentration (C=Y/Q) to characterize the variability and predictability of river total nitrogen (TN) and total phosphorus (TP) inputs to the Great Lakes. Our approach considered criteria including slope of the C~Q relationship, and strength of the C~Q relationship. Several catchments were prone to high episodic transport that is tightly linked to precipitation (slope>1 and r2>0.5). Others were prone to episodic transport that was difficult to predict from Q, which presents a management problem. Our work indicates river responses to precipitation variability are affected largely by landscape variables including the intensity of agriculture, catchment slope, and presence of upstream lakes, reservoir, and wetlands. Quantifying linkages between landscape characteristics and the variability of pollution transport could help predict outcomes under changing land use, and quantify uncertainty or risk of future episodes.
Keywords: Watersheds, Rivers, Phosphorus, Nitrogen, Reservoirs.

PREZIOSI, D.[1] and PASTOROK, R.[2], [1]Integral Consulting Inc., 4D Bay Street, Berlin, MD, 21811; [2]Integral Consulting Inc., 411 1st Avenue S., Seattle, WA, 98104. **Ecological Relevance of Great Lakes Chemicals of Emerging Concern - Part 2, The Role of Ecosystem Services Assessment.**

In the second of our two talks, we continue in our presentation on the need to move beyond screening and listing of emerging chemicals of concern so that more meaningful insight can be gained on potential ecological impacts these chemicals may pose to aquatic populations and the wildlife that depend on them in the Great Lakes basin. In our first talk, we presented on the use of USEPA's ecological risk assessment paradigm to determine the ecological relevance of listed chemicals in terms of their potential ecological risk in the Great Lakes ecosystem. In this talk we extend the paradigm to include the assessment of ecosystem services. The ecosystem services concept has continued to grow in popularity as an approach that be used to better inform policy and planning based on ecosystems and the benefits they provide to humans. A variety of economic-based models have been used in developing management paradigms associated with ecosystem services. Here we present on an emerging set of ecology-based models that provide information on ecological factors controlling ecosystem services, and how these tools can be applied in the evaluation of emerging chemicals in the Great Lakes. *Keywords: Environmental contaminants, Ecosystem services, Ecosystems, Decision making.*

PRICHARD, C.G.[1], KOCOVSKY, P.M.[2], and STEPIEN, C.A.[1], [1]Great Lakes Genetics Lab, Lake Erie Center, 6200 Bayshore Rd, Oregon, OH, 43616; [2]Great Lakes Science Center, Lake Erie Biological Station, 6100 Columbus Ave, Sandusky, OH, 44857. **Comparative Population Genetics of Bighead and Silver Carps: Invasion Fronts Approaching the Great Lakes.**

Of top ecological concern is the impending invasion of bighead and silver (collectively "Asian") carp populations that are rapidly spreading throughout much of the Mississippi River watershed, with three primary fronts at the gates of the Great Lakes. However, almost nothing is known of the fundamental population genetic variability underlying the spread of Asian carp in North America. Here, we characterize Asian carp population genetics from three areas: (1) the northward extent of the Illinois River (near southern Lake Michigan), (2) the Wabash River (the population approaching the Maumee River system near Fort Wayne, IN), and (3) the upper Mississippi River approaching Minneapolis/St. Paul, MN. We examine the comparative population genetic structure at invasion front populations using two mtDNA genes (COI (barcode) and cytochrome-*b*) and a suite of nuclear microsatellite loci. Additionally, we assess and characterize the extent of hybridization between bighead and silver carp at invasion front populations, which may significantly affect their ecology, invasiveness, and success in new habitats. Loci distinguishable between silver and bighead carp are used in conjunction with the aforementioned mtDNA genes for hybridization analysis, which will assist managers in developing appropriate control strategies. *Keywords: Invasive species, Genetics, Carp.*

PRICHARD, C.G.[1], BLOMQUIST, T.[2], WILLEY, J.C.[2], SIGLER, W.V.[3], and STEPIEN, C.A.[1], [1]Great Lakes Genetics Lab, Lake Erie Center, 6200 Bayshore Rd, Oregon, OH, 43616; [2]George Isaac Research Center, 3000 Arlington Ave, Toledo, OH, 43614; [3]Department of Environmental Scienes, University of Toledo, 2801 W Bancroft St, Toledo, OH, 43606. **Rapid Detection and Quantification of Existing and Potential Invasive Fish Species Using Environmental DNA and Next-Generation Sequencing.**

>186 non-native species are established in the Great Lakes, of which 25 are fishes, and many are of primary management concern. This project identifies the presence and abundance of all current and projected invasive fish species through a rapid, inexpensive, and easy-to-use next-generation sequencing (NGS) test, applicable for eDNA in water samples. This test is designed to simultaneously identify and quantify existing and predicted species, including snakehead, Asian carps, Ponto-Caspian gobies, sea lamprey, alewife, etc. from a single water sample. Designed primers target species-specific sequences from the mtDNA barcode (COI) and cytochrome-*b* genes, and the nuclear RAG1 gene in ~100 bp pieces, and diagnosis uses quantitative NGS. Our test results are being ground-truthed using water samples collected in summer 2012 by the Ohio EPA, and verified by fish counts taken concurrently using electrofishing and netting. This test is designed to: (1) improve the ability to detect and quantify invasive species at low abundances to facilitate rapid response actions, (2) help stop the introduction of new invasive species through enhanced surveillance (e.g., ballast water), and (3) control and reduce the spread of invasive species already present in the ecosystem through up-to-date provision of critical management information. *Keywords: Genetics, Invasive species, Fish.*

PRITT, J.J.[1], DUFOUR, M.R.[1], MAYER, C.M.[1], KOCOVSKY, P.M.[2], TYSON, J.T.[3], WEIMER, E.J.[3], VANDERGOOT, C.S.[3], and STOW, C.A.[4], [1]University of Toledo Lake Erie Center, Department of Environmental Sciences, 6200 Bayshore Rd., Oregon, OH, 43616; [2]US Geological Survey, Lake Erie Biological Station, 6100 Columbus Ave, Sandusky, OH, 44870; [3]Sandusky Fisheries Research Unit, Ohio Department of Natural Resources, Division of Wildlife, 305 East Shoreline Drive, Sandusky, OH, 44870; [4]National Oceanic and Atmospheric Administration, Great Lakes Environmental Research Laboratory, 4840 South State Road, Ann Arbor, MI, 48108. **Abundance and Ecology across Life Stages: Walleye Reproduction in the Maumee River.**

Walleye (*Sander vitreus*) in Lake Erie is a valuable and migratory species that spawns in tributaries. We used hydroacoustic sampling, gill net sampling, and Bayesian state-space modeling to estimate the spawning stock abundance, characterize size and sex structure, and explore environmental factors cuing migration of walleye in the Maumee River for 2011 and 2012. In addition, we conducted larval fish sampling and used a Bayesian state-space model to estimate the number of larval walleye produced in the Maumee River and determine the factors controlling production. We estimated the adult abundance to be 651,000 individuals in 2011 and 543,000 individuals in 2012. The sex ratio was skewed towards males early in the spring but approached 1:1 later, and larger walleye entered the river earlier in the season than smaller individuals. Walleye migration was greater during low river discharge and intermediate temperatures. We found that annual larval walleye production varied greatly, from 87 million in

2011 to 6.5 million in 2012. Larval fish production was positively correlated with warm temperatures and high discharge and showed little relationship to the number of adult spawners. Our approach could improve assessment and management of this species and our methodology is applicable to other diadromous populations. *Keywords: Hydroacoustics, Mitigation, Walleye.*

RAM, J.L., Department of Physiology, Wayne State University, Detroit, MI, 48201. **Molecular Methods for Live-Dead Analysis of Microorganisms in Ballast and Environmental Waters.**

Keeping invasive species out of the Great Lakes is a high priority for protecting Great Lakes ecosystems. Recent and soon to be implemented regulations will require ships entering the Great Lakes to reduce the number of viable organisms discharged with ballast water to very low levels by means of both ballast water exchange and ballast water treatment. The Ram Lab is currently developing molecular techniques to verify the efficacy of these water treatments and to assess the risk associated with microorganisms that survive the treatments. PMA-PCR was used to amplify 16S rDNA in bacteria and rbcL in algae from only the survivors of various water treatments (e.g., chlorine and others). These methods have been applied to environmental water and to ballast intake and discharge samples from ballasted ships in the Great Lakes. A second approach, which we are currently automating, is to use the ability of live organisms (but, generally, not dead ones) to generate a fluorescent product from fluorescein diacetate. Automated systems should also be feasible for processing shipboard samples for subsequent land-based PMA-PCR analysis. The goal is to install tools with treatment systems to monitor treatment efficacy and with post-sample processing to assess the risk of organisms transported into the Great Lakes in ballast. *Keywords: Ballast, Bacteria, Invasive species, Algae, Measuring instruments, Ribosomal DNA gene.*

RAMA, S., BANNO, F., SOUTHERN, J.A., DAHLSTROM, A.A., GALA, R.R., GIZICKI, J.P., KASHIAN, D.R., and RAM, J.L., Wayne State University, Detroit, MI, 48201. **Benthic Sampling to Detect Non-Indigenous Species in the Toledo Harbor Region of Lake Erie.**

Toledo Harbor (Maumee River and Maumee Bay, Ohio) is a "port of concern" for introduction of non-indigenous species into the Great Lakes due to the large volume of ballast water discharged from outside the Great Lakes, its amenable habitat, and the significant transport of ballast from Toledo, making it a potential source of invasive species throughout the region. To estimate sampling intensity needed to detect non-indigenous species, 87 benthic grab samples from >25 locations near Toledo Harbor were collected during fall, 2010 and summer, 2012. Morphological taxonomic criteria and cytochrome oxidase I sequence barcodes identified >70 different taxons (>25 to species level) in the samples, including non-indigenous taxons (Branchiura sowerbyi, Bithynia tentaculata, Corbicula fluminea, Dreissena polymorpha, D. bugensis, and others), some of which have not been reported before in Ohio. Taxon accumulation curves are still rising, indicating that many taxons are yet undetected. Differences between identifications by our certified taxonomists and reference sequences in Genbank and other databases need to be resolved, following which estimates of sampling effort to achieve "oversampling" (>90% of species detected) can be evaluated using the Chao asymptotic richness estimator. *Keywords: Benthos, DNA sequences, Lake Erie, Taxonomy, Invasive species, Oligochaetes.*

RAMIN, M. and ARHONDITSIS, G.B., University of Toronto, 1265 Military Trail, Toronto, ON, M1C 1A4. **Bayesian synthesis of predictions from different models for setting water quality criteria in Hamilton Harbour, Ontario, Canada.**

We present a critical approach to modelling that focuses on the integration of Bayesian inference techniques with mathematical modelling for improving ecological forecasts and management actions over space and time, while accounting for the uncertainty underlying model predictions. The case study for the dissemination of the benefits of this research has been the Hamilton Harbour, Ontario. This system was selected due to its eutrophic status and adjacency to an urban area, where environmental concerns need to be integrated with socioeconomic values. We have developed several models intended to support management decisions by assessing the exceedance frequency and confidence of compliance with different water quality standards. We also consider the fact that there is no true model of an ecological system and propose an averaging scheme for obtaining weighted averages of the forecasts from multiple models of varying complexity. Our work predicts that the water quality goals for TP levels <20 μg/L, and chla between 5-10 μg/L will likely be met, if the proposed phosphorus loading reductions at the level of 142 kg/day are actually achieved. It is also emphasized that the predictive capacity of any modelling exercise in the Harbour is conditional upon the credibility of the contemporary nutrient loading estimates. *Keywords: Mathematical models, Bayesian inference, Ecosystem modeling, Model testing.*

RAYMER, Z.B.[1], SHUCHMAN, R.A.[1], BROOKS, C.N.[1], SAYERS, M.J.[1], and VANDER WOUDE, A.J.[2], [1]Michigan Tech Research Institute, 3600 Green Ct., Ste. 100, Ann Arbor, MI, 48105; [2]CILER, University of Michigan, School of Natural Resources and Environment, G110 Dana Building, 440 Church Street, Ann Arbor, MI, 48109. **A Robust Satellite Algorithm for River Plume Mapping within the Great Lakes Basin.**

A robust multi-platform algorithm has been developed for mapping river sediment plumes in the Great Lakes. The algorithm uses blue, green and near infrared spectral bands, which can be found on many satellite and airborne sensors. The algorithm has been optimized for use with the MODIS Aqua platform (and soon the NPP VIIRS sensor) to perform large scale mapping of sediment plumes in EPA Area of Concern sites throughout the Great Lakes. The algorithm is built from the principles of the NDVI algorithm, exploiting the reflection differences in the most and least reflective wavelengths relative to water. The algorithm's utility across multiple sensing platforms gives it the flexibility to map large river plumes in open expanses of water or much smaller coastal river plumes. The strength, or relative sediment load, of the plume has been determined by comparing algorithm index values to field data to develop plume strength classifications. Also estimated is the total loading from the sediment plume by combing plume area and bathymetric data. The robustness of the algorithm, especially when combined

with ancillary data, enables it to be a very useful tool for monitoring areas affected by sediment plumes. *Keywords: Sediments, Remote sensing, Turbidity.*

REA, C.L., BISESI, M.S., and LEE, J., 1841 Neil Ave., Cunz Hall, Columbus, OH, 43210.
Wetland Ecoservices Protect Beach Water Quality from Avian-Associated Pathogens and Fecal Contamination in Lake Erie.

Health hazards can emerge as a result of avian species' ability to carry and disperse pathogens over vast distances. Wetlands are thought to provide human health-related ecoservices--including water filtration--but many wetlands host enormous bird populations, sometimes very close to swimming beaches. The specific aims of this study were to characterize: 1) pathogen presence in Canada Geese populations and nearby waterways; 2) transport patterns via water to determine if a wetland has the ability to reduce pathogen loads to safer levels for human exposure. Sampling sites were located within Ottawa National Wildlife Refuge and at an adjacent southwestern Lake Erie swimming beach. Weekly sampling occurred during summer 2012. ELISA results showed 39.1% of Canada Goose fecal samples were positive for *Cryptosporidium* specific antigen. Water-sampling results indicate that *E. coli* are highest where water enters the wetland and are lowest where water flows out of the refuge. Even with large populations of birds, the wetland reduces *E. coli* levels to safe ranges prior to water reaching Lake Erie and nearby beach waters. Study findings support the idea that intact ecosystems can function in a disease-regulating role and provide important water filtration ecoservices that protect human health. *Keywords: Coastal wetlands, Water quality, Human health.*

REAVIE, E.D.[1], CHRAÏBI, V.[2], ALLINGER, L.E.[1], and KIRETA, A.R.[1], [1]University of Minnesota Duluth, Natural Resources Research Institute, Ely, MN, 55731; [2]University of Nebraska-Lincoln, Department of Earth and Atmospheric Sciences, Lincoln, NE, 68588. **Algal Paleolimnology of the Laurentian Great Lakes.**

Monitoring and paleolimnological data from the Great Lakes have revealed dramatic food web changes in the last 200 years and particularly within the last decade. These retrospective data are needed to distinguish natural from human trends, and to reveal the causes and magnitudes of environmental insults that inform management matters regarding climate change, pollution and invasive species. Phytoplankton collections have been valuable to track recent changes in the Great Lakes, but contemporary monitoring alone has not been sufficient. The cornerstone of many previous investigations has been the use of diatoms; known powerful indicators of environmental change. Historical diatom data from the lakes have been compiled into a chronological database. A new multivariate tool integrating monitoring and paleoecological collections has been developed to put modern phytoplankton assemblages in a long-term context. Further, new paleolimnological studies on all of the lakes are under way. A diatom-based inference model, derived using monitoring data, is being used to infer past nutrient conditions in the lakes. It is anticipated that algal indicators and paleoecological applications will serve to address the myriad of environmental issues that require long-term data in order to make

remedial decisions. *Keywords: Paleolimnology, Indicators, Diatoms, Monitoring, Phytoplankton, Climate change.*

REDDER, T.M., MCCULLOCH, R.D., GRUSH, J.O., and DEPINTO, J.V., 501 Avis Drive, Ann Arbor, MI, 48108. **Development, Calibration, and Application of Integrated Modeling Tools for Assessing Current and Future Sedimentation Conditions in Great Lakes River Mouth Systems.**

Sediment management is a significant challenge in many Great Lakes harbors, where frequent dredging maintenance of navigational systems is often required. Toledo Harbor, which provides navigational access from Lake Erie through the lower 10 miles of the Maumee River, provides a prominent example of these challenges. The navigation channel in Toledo Harbor is subject to significant rates of sedimentation resulting from the combined effects of suspended sediment loading from the Maumee River and wind-wave resuspension and redistribution of bed sediments in Maumee Bay. One of the specific measures of progress included in the GLRI Action Plan is a 2.5% reduction in sediment deposition in the Harbor by 2014. Evaluating potential reductions in sedimentation rates for such a complex system requires the integration of all pertinent sediment data into predictive modeling tools. Such an integrated assessment has been conducted on behalf of the USACE for Toledo Harbor, with the expectation that it can serve as a template for addressing similar sediment issues in other Great Lakes river mouth systems. A summary of the key findings from a bathymetric data analysis, calibration of a sediment transport model, and application of the sediment model to pre- and post-2009 loading conditions will be presented. *Keywords: Sediment transport, Model studies, Deposition, Great Lakes Restoration Initiative (GLRI).*

REDISKE, R.R.[1] and RILEY, J.[2], [1]Annis Water Resources Institute, Grand Valley State University, Muskegon, MI, 49401, United States; [2]Michigan Department of Environmental Quality, Office of the Great Lakes, Lansiong, MI, 48909. **Delisting BUIs in the White Lake Area of Concern.**

White Lake was listed as an Area of Concern (AOC) by the International Joint Commission in 1987 because of severe environmental impairments related to the historic discharge of municipal and industrial wastes. Eight Beneficial Use Impairments (BUIs) were identified as present in the AOC. The process of delisting three BUIs (Degradation of Benthos, Restrictions on Fish and Wildlife Consumption, and Eutrophication and Undesirable Algae) is described from target setting to agency approval. The delisting target setting process was started in 2003 with final approval by Michigan Department of Environmental Quality in 2009. Research investigations of water quality and benthic macroinvertebrate assemblages were conducted that compared historical to current conditions, with the goal of demonstrating progress toward restoration. Fish contaminant surveys were conducted in 2006 and 2011, comparing White Lake to a reference system. The results were presented to stakeholders in 2012 and the requests to delist the BUIs were submitted. The delisting of two BUIs was approved by USEPA and the remaining one is under review. Key components in the successful process were clear and

demonstrable targets, sound scientific research, stakeholder involvement, and responsive oversight and assistance from state and federal agencies. *Keywords: Benthos, Areas of Concern, Mercury, Delisting, PCBs.*

REDMAN, R.A. and CZESNY, S.J., University of Illinois, Illinois Natural History Survey, Lake Michigan Biological Station, 400 17th Street, Zion, IL, 60099. **Size Structure of Female Yellow Perch Spawners as an Early Indicator of Year Class Strength.**

Yellow perch, *Perca flavescens*, in Lake Michigan have undergone severe fluctuations in abundance over the past three decades and recruitment has been increasingly erratic. Management of this valued sport fish is hampered by insufficient information about reproductive ecology and early life history traits. We examined temporal variation in spawning assemblage composition and fecundity with an attempt to investigate the role of female size on offspring characteristics. Adult yellow perch were collected at two historical spawning sites in southwestern Lake Michigan. Fish were measured, weighed and fecundity of gravid females was estimated. Moreover, a subset of ripe females was stripped of eggs, which were fertilized in the field, incubated and hatched to evaluate variation in size at hatch and oil globule volume. Spawning stock assessments indicated little temporal variation in annual relative abundance of female spawners; however, the size structure of female spawners varied among sample years. Fecundity of yellow perch increased exponentially with length and larger females typically produced bigger larvae with more energy reserves. Our results provide evidence that temporal changes in the size structure of female spawners can impact egg production, hatching success and ultimately recruitment success of yellow perch. *Keywords: Yellow perch, Reproduction, Lake Michigan, Early life history.*

REED, A.J.[1], BADGLEY, J.B.[2], WELCH, J.B.[1], SLOAN, C.M.[1], SADOWSKY, M.J.[3], and HICKS, R.E.[1], [1]Department of Biology, University of Minnesota Duluth, SSB 207, 1035 Kirby Drive, Duluth, MN, 55812; [2]Department of Crop & Soil Environmental Sciences, Virginia Polytechnic Institute and State University, 328A Smyth Hall, Blacksburg, VA, 24061; [3]Department of Soil, Water and Climate, University of Minnesota, 258 Borlaug Hall, 1991 Upper Buford Circle, St.Paul, MN, 55108. **Molecular Detection of Potentially Harmful Bacteria Discharged into the Duluth-Superior Harbor in the Ballast Water of Commercial Ships.**

Samples of untreated ballast water from 24 large commercial ships deballasting in the Duluth-Superior Harbor (DSH) were collected between 2010 and 2012. The 16S rDNA was sequenced using next-generation Illumina sequencing to identify bacteria resident in ballast water samples. Sequences were cross referenced to a database of bacteria that are potentially harmful to humans, fish, or wildlife or are environmentally disruptive. Sequences from relatively few traditional indicator bacterial genera (*Vibrio, Escherichia, Enterococcus,* etc.) were detected but sequences from other often overlooked and potentially harmful bacteria were found, including: *Acinetobacter, Clostridium, Aeromonas, Piscirickettsia and Tenacibaculum. Tenacibaculum* is a genus containing numerous marine fish pathogens and constituted 1.2%

(2083 sequence copies) of the ballast water sequences obtained from a seagoing ship in the DSH. Next-generation Illumina sequencing can relatively quickly detect rare sequences of interest that may well be missed by other detection methods. Identifying bacteria from genera containing harmful strains in ship ballast water after a mid-ocean ballast water exchange indicates that potentially harmful bacteria may be transported, discharged, and go undetected under current ballast water management practices. *Keywords: Invasive species, Bacteria, Species diversity, Illumina sequencing, Microbiological studies, Ballast water.*

REEVES, H.W., HOLTSCHLAG, D.J., and LUUKKONEN, C.L., USGS Michigan Water Science Center, 6520 Mercantile Way, Suite 5, Lansing, MI, 48911. **Development and Implementation of methods to estimate ungaged streamflows and track water use in the Great Lake Basin.**

Time series of ungaged streamflows are being estimated for the Great Lakes Basin using methods that combine conservation of flow through the NHDPlus dataset describing the stream network and regression methods based on available landscape and climate variables. The estimation system, known as AFINCH, also accounts for water use in the system and provides the ability to track water removals or augmentations through the stream network. Such a system may ultimately be used to assess the impact of water withdrawals on the system and to illustrate the effects of water conservation efforts on streamflow volumes and timings.
Keywords: Watersheds, Great Lakes basin, Management.

REID, A.H. and SPRULES, W.G., University of Toronto at Mississauga, Department of Ecology and Evolutionary Biology, 3359 Mississauga Road, Mississauga, ON, L5L 1C6. **The Impacts of Heterogeneous Phytoplankton Distributions on *Daphnia pulex* Productivity and Fitness.**

The heterogeneity of phytoplankton distributions is a well-documented phenomenon, yet current models of grazing zooplankton foraging assume homogeneous distributions. We hypothesize that feeding in heterogeneous prey distributions increases the net energy gain for zooplankton, thus allowing for increased production and fitness. Previous modeling work has shown that the spatial distribution of algae should have a substantial impact on the foraging success of zooplankton; additionally zooplankton abundance has been correlated with such distributions in marine systems. To test this a series of homogeneous and heterogeneous distributions of the algal prey Ankistrodesmus sp. were created in 3L chambers in the lab using a combination of temperature and salinity gradients. The individual growth and fecundity of grazing Daphnia pulex were measured to test the assertion that growth and reproduction are greater in patchy prey. Results will be discussed in the context of spatial processes and trophic interactions. *Keywords: Optimal foraging, Spatial distribution, Bioenergetics, Area-restricted search, Food chains, Zooplankton.*

REISINGER, A.J. and TANK, J.L., Department of Biological Sciences, University of Notre Dame, Notre Dame, IN, 46556. **The Influence of Land-Use on Pelagic Nutrient Uptake Along the River Continuum in Two Contrasting Lake Michigan Watersheds.**

Excess nutrients from human land-use impair water quality in the Great Lakes Basin and can be retained in streams and rivers prior to delivery to the lakes. Although nutrient retention generally occurs in biofilms on stream bottoms, the pelagic zone is predicted to become important in larger systems due to increased water depth. Additionally, land-use affects nutrient retention via changes in background nutrient concentrations and turbidity which can inhibit or saturate nutrient uptake. To determine the effect of land-use on pelagic processes, we measured pelagic nutrient uptake in streams and rivers across a size gradient (discharge range: 46-55,000 L/s) in two contrasting Lake Michigan watersheds. The St. Joseph Basin is >90% agricultural with high background nutrients, whereas the Manistee Basin is mainly forested with low background nutrients. Pelagic uptake was measurable in both basins and consistently increased with stream size. Nitrate uptake was more variable than ammonium or phosphate uptake, and sites in the agricultural basin had higher nitrate uptake rates than sites in the forested basin. Surprisingly, phosphate uptake did not differ between basins. Pelagic uptake has the potential to mitigate nutrient pollution entering the Great Lakes, but can be influenced by land-use in the surrounding basin. *Keywords: Water quality, Biogeochemistry, Nutrients.*

RENEAU, P.C.[1], FITZPATRICK, F.A.[1], and CARLSON MAZUR, M.L.[2], [1]8505 Research Way, Middleton, WI, 53562; [2]Boston College, Devlin 213, 140 Commonwealth Avenue, Chestnut Hill, MA, 02467. **Role of Spatial and Temporal Interactions of Water Levels and Flows in Determining Physical Habitat Structure of Great Lakes Rivermouths.**

Little is known about the physical controls of habitat structure in Great Lakes' rivermouths, even though these zones are important for aquatic food-web processes and biological productivity. The physical habitat is controlled by a dynamic combination of flows and sediment inputs from tributaries as well as lake currents and sieches. The interaction of these sources of flows and sediment can vary on many different time scales, depending on precipitation, wind patterns, snowmelt, and lake levels. The U.S. Geological Survey is studying water levels and velocity patterns in selected rivermouths as part of a larger study of the ecological functions of Great Lakes' rivermouths being conducted for the Great Lake Restoration Initiative. From May to November, 2011, continuous water levels and frequent repeat transects of velocity with an Acoustic Doppler Current Profiler were measured in two rivermouths directly opposite each other on Lake Michigan - the Manitowoc River on the west side and the Pere Marquette River on the east side. These two rivermouths showcase the dynamic nature of the interplay of tributary flows and lake-effect currents. These baseline data are important for rehabilitation of the river mouths as well as in watersheds and coastal areas long the Great Lakes.
Keywords: Estuaries, Great Lakes Restoration Initiative (GLRI), Habitats.

RICHARDS, R.P.[1], BAKER, D.B.[1], BRIDGEMAN, T.B.[2], DEPINTO, J.V.[3], REUTTER, J.M.[4], and STUMPF, R.P.[5], [1]NCWQR, Heidelberg University, 310 E. Market St., Tiffin, OH, 44883; [2]Lake Erie Center, University of Toledo, Oregon, OH, 43618; [3]LimnoTech, Ann Arbor, MI, 48108; [4]The Ohio State University, Columbus, OH, 43212; [5]NOAA National Ocean Service, Silver Spring, MD, 20910. **Phosphorus Loading and Cyanobacteria Blooms in Western Lake Erie in 2011 and 2012: A Study in Contrasts.**

Cyanobacteria blooms in the Western Basin of Lake Erie have increased in severity for most of the last decade, culminating in a major, long-lasting bloom in 2011 that extended well into the Central Basin. By contrast, the bloom of 2012 was relatively minor. Annual loads of phosphorus, both total and dissolved, from the Maumee River for these two years were quite comparable in magnitude, but differed in timing. In particular, springtime loads were large in 2011 but very much smaller in 2012. Several studies have identified springtime loads as being a determining factor for bloom development, and the contrast between these two years supports this finding. This two-year natural experiment indicates that the Western Basin is capable of responding rapidly to changes in nutrient inputs. It also suggests that internal loading is of secondary importance in determining bloom magnitude. Since loading from the Detroit River should have been nearly the same in both years, the difference in the blooms argues that loading of phosphorus from the Detroit River at low concentrations is not a major factor in bloom development. *Keywords: Phosphorus, Harmful algal blooms, Lake Erie.*

RICHARDSON, W., LARSON, J., VALLAZZA, J., VELDBOOM, J., BARTSCH, L., BARTSCH, M., and NELSON, J.C., US Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, WI, 54603. **Seston and Consumer Fatty Acid Content from Tributaries, Rivermouths and Nearshore Lake Michigan: Effects of Landscape Disturbance.**

Particulate matter (seston) transported from catchments may play a role in supporting productivity of rivers, rivermouths, and lakes. Fatty acid (FA) content of transported material indicates potential food quality for seston consumers. We explored the variation FA quality and quantity in seston and invertebrate seston feeders (zebra mussels [ZM] in rivermouths and lake nearshore; hydropsychid caddis larvae [HC] in rivers) of 11 Lake Michigan tributaries in September, 2010. Seston FAs were in greatest concentration by volume ($\mu g \cdot L^1$) in rivers, but greatest by mass ($\mu g \cdot mg^1$) in Lake Michigan, suggesting river water carried large quantities of low-quality particles, while relatively sparse lake seston was rich in FAs. River seston total FA mass was inversely correlated with percent forested buffer and positively correlated with percent agricultural landuse. FA concentration of ZM in rivermouths was generally greater than those in nearshore lake areas, at tributaries draining disturbed landscapes (%urban+% rowcrop). FA concentration of HC was also greatest in rivers draining disturbed landscapes. Landscape disturbance appears to contribute large amounts of low quality seston to rivers and rivermouths, which is beneficially assimilated by seston-feeding invertebrates. *Keywords: Zebra mussels, Seston, Estuaries, Fatty acids, Great Lakes Restoration Initiative (GLRI), Hydropsychids.*

RIGGS, M.K. and BASCH, M.E., 402 West Washington Street, Room W264, Indianapolis, IN, 46204. **Status of Water Use Registration, Permitting and Water Conservation and Efficiency Efforts as required by Indiana's Implementation of the Great Lakes Compact.**

The State of Indiana has collected and maintained an inventory of significant uses of ground water and surface water since 1985 in accordance with the Water Resources Management Act (IC 14-25-7). Section 15 of the act requires the registration of all significant water withdrawal facilities (SWWF) and annual reporting of water use. A SWWF is defined as "the water withdrawal facilities of a person that, in the aggregate from all sources and by all methods, has the capability of withdrawing more than one hundred thousand (100,000) gallons of ground water, surface water, or ground and surface water combined in one (1) day". Registration and permitting of SWWFs continue within the Great Lakes Basin in accordance with withdrawal thresholds set forth by Indiana's implementation of the Great Lakes Compact under IC 14-25-15 and by Temporary Rule. Mandatory and voluntary water conservation are also implemented by statute and rule consistent with the conservation and efficiency objectives set forth in Resolution 5 of the Great Lakes Compact. There are 879 facilities currently registered in the basin with a total withdrawal capacity of approximately 7.8 billion gallons-per-day, and reported withdrawals of 893 billion gallons in 2011. *Keywords: Assessments, Water Use, Compact.*

RILEY, S.[1], SLEEMAN, J.[2], LAFRANCOIS, B.[3], BOOTSMA, H.A.[4], KENOW, K.P.[5], BLEHERT, D.[2], WHITE, L.[2], CHIPAULT, J.[2], HAACK, S.[6], ISAACS, N.[6], and FARHA, S.[1], [1]U.S. Geological Survey, Great Lakes Science Center, Ann Arbor, MI; [2]U.S. Geological Survey, National Wildlife Health Center, Madison, WI; [3]U.S. National Park Service, Ashland, WI; [4]University of Wisconsin-Milwaukee, School of Freshwater Sciences, Milwaukee, WI; [5]U.S. Geological Survey, Upper Midwest Environmental Science Center, La Crosse, WI; [6]U.S. Geological Survey, Michigan Water Science Center, Lansing, MI. **Avian Botulism in Distressed Lake Environments: Lessons learned from a multi-year, multi-agency collaborative study.**

Type E avian botulism, which causes the paralysis and death of fish and birds, is caused by ingestion of neurotoxins produced by the bacterium *Clostridium botulinum*. Periodic outbreaks of type E botulism have resulted in die-offs of fish and fish-eating birds in the Great Lakes since at least the 1960s. Extensive botulism-related bird mortality near Sleeping Bear Dunes National Lakeshore has caused great public concern, but the physical and ecological factors associated with botulism outbreaks remain largely unknown. In 2010, a joint National Park Service and United States Geological Survey collaborative effort was launched under the Great Lakes Restoration Initiative, with the primary objectives of: 1)development of an *in vitro* assay for detection of botulinum toxin, 2)characterization of the distribution of foraging waterbirds, 3)enhanced epidemiological investigations of current and historic outbreaks, and 4)determining the trophic pathways by which fish and birds are exposed to botulinum toxin in Great Lakes food webs. This presentation will discuss the study approach being used to achieve these objectives and synthesize preliminary observations from the first two years of the study.
Keywords: Great Lakes Restoration Initiative (GLRI), Avian ecology, Fish toxins.

RINCHARD, J.[1], FANSLOW, D.[2], NALEPA, T.F.[2], HÖÖK, T.O.[3], and SEPULVEDA, M.S.[3], [1]The College at Brockport - SUNY, 350 New Campus Drive, Brockport, NY, 14420; [2]NOAA-GLERL, 4840 S. State Rd, Ann Arbor, MI, 48108; [3]Depart,emt of Forestry and Natural Resources, Purdue University, 195 Marsteller Street, West Lafayette, IN, 47907. **Lipid Content and Fatty Acid Signatures of Diporeia: Spatio-Temporal Variation in the Great Lakes.**

Since the 1990's, the amphipod Diporeia has experienced dramatic decline in the Great Lakes, except Lake Superior. Their decline has coincided with the introduction and establishment of dreissenid mussels. To better understand physiological conditions of Diporeia, juvenile and adult were collected from multiple sites in Lakes Huron, Michigan, Ontario, Superior and Cayuga Lake during summer and fall 2008 and 2009. Mean lipid content ranged from 2 to 71%. For both life stages, lipid content did vary significantly among lakes with the highest content found in L. Ontario and the lowest in L. Huron. Both life stages were characterized by high concentrations of 22:6n-3 in Lake Ontario. Our results clearly indicated that in both life stages, total lipid, lipid classes and fatty acid signature of Diporeia varied spatially, seasonally and annually. *Keywords: Diporeia, Amphipods, Great Lakes basin.*

RISENG, C.M.[1], WILEY, M.J.[1], HYNDMAN, D.[2], PIJANOWSKI, B.C.[3], STEVENSON, R.J.[2], NOBLES, G.[4], and KOCHES, J.[5], [1]G170 Dana, 440 Church St., Ann Arbor, MI, 48109-1041; [2]Michigan State University, 206 Natural Sciences, East Lansing, MI, 48824; [3]Purdue University, 195 Marsteller St, West Lafayette, IN, 47906; [4]Ferris State University, 1009 Campus Dr, Big Rapids, MI, 49307; [5]Grand Valley State University, 740 West Shoreline Drive, Muskegon, MI, 49441. **Restoring the Muskegon River watershed.**

The Muskegon River Watershed Partnership(MRWP), a collaboration of university researchers, scientists and local and state managers, developed, calibrated, and implemented a system of hydrologic, hydraulic, habitat, and biological models for the watershed. Scenarios representing different, plausible versions of future land use management were developed with participation of local and state organizations and used to simulate the effects of different scenarios on the Muskegon River ecosystem. Simulations through 2100 suggested that continuing current land use trends will result in increasing rates of sediment erosion, nutrient loading to Muskegon Lake and declining conditions for biotic communities. Increasing forest land cover, especially along riparian corridors, was found to ameliorate many of these trends. These results provided local organizations with scientific support to revise the Muskegon River Watershed Management Plan, target high-priority subwatersheds for restoration and conservation, and obtain GLRI funding for targeted watershed reforestation.MRWP analyses also contributed to new restoration initiatives focused on Muskegon Lake, the lower river, and headwater lakes and influenced regional policy decisions (e.g. Michigan's new water withdrawal regulations) that positively impact local and regional sustainability. *Keywords: Watersheds, Conservation, Model studies.*

RITZENTHALER, A.A.[1], FRY, L.M.[1], ANDERSON, E.J.[2], CAMPBELL, K.[1], and GRONEWOLD, A.D.[2], [1]Cooperative Institute for Limnology and Ecosystems Research, University of Michigan, Ann Arbor, MI; [2]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI. **Development of a multimodel framework linking a pathogen loading model to a hydrodynamics model for beach water quality forecasting.**

Forecasting pathogen loadings from watersheds and the resulting impacts on near shore water quality remains a key challenge in promoting safe use of Great Lakes beaches. To address this challenge, we are developing a multimodel framework for use in operational forecasting for beaches near the Clinton River outlets. The multimodel framework consists of first encoding a simple wash-off model that predicts pathogen accumulation, terrestrial losses, and wash-off from landscape characteristics into the IHACRES lumped parameter conceptual rainfall-runoff model within the Hydromad modeling framework. Output is then used as input to an FVCOM hydrodynamic particle tracking model (Huron-Erie Connecting Waterways Forecasting System - HECWFS) to predict pathogen concentrations along the nearshore zone. Weekly samples collected along the shoreline and within the Clinton River channels during the first year of an intensive monitoring program provide a basis for development and validation of the models. We will present the initial results from calibration and validation of the hydrological model and a comparison of modeled to measured loadings at the two Clinton River outlet channels, as well as verification of the near shore concentrations predicted by the hydrodynamic component.
Keywords: Pollution load, Water quality, Hydrodynamics.

ROBERTSON, D.M. and SAAD, D.A., U.S. Geological Survey, 8505 Research Way, Middleton, WI, 53562. **Recent Progress in SPARROW Watershed Modeling in the Great Lakes Basin.**

To help address eutrophication problems in the Great Lakes, SPARROW (SPAtially Referenced Regression On Watershed attributes) models were recently developed to simulate phosphorus (P) and nitrogen (N) loading in streams throughout the Upper Midwest part of the United States. Results from these SPARROW models were used to: 1) estimate P and N loads to each Great Lake; 2) rank all U.S. tributaries with drainage areas greater than 150 km2, based on total loads and relative yields; and 3) determine the relative magnitude of P and N inputs from major sources (atmospheric, point sources, fertilizers, manure, fixation, and forested and urban lands). A binational modeling effort is now underway with Canada to develop SPARROW models for P and N for the entire Great Lakes Basin. These models are being developed using much smaller catchments (delineated using the National Hydrography Dataset Plus-NHD Plus) to enable improved spatial descriptions of where and from what sources the P and N originate and calibrated using more accurate loads, including more data from smaller watersheds, than used in previous models. To forecast changes in nutrient loads associated with various future climate-change and land-use change scenarios, a new model that links SPARROW with outputs from water-quantity models, called HydroSPARROW, has been developed.
Keywords: Nutrients, Model studies, Great Lakes basin.

ROBINSON, A.M.[1], VANNIER, R.G.[1], LONG, D.T.[1], GIESY, J.P.[2], KANNAN, K.[3], BRADLEY, P.W.[4], and VOICE, P.T.C.[5], [1]Geological Sciences, Michigan State University, East Lansing, MI; [2]Dept. Veterinary Biomedical Sciences and Toxicology Centre, University of Saskatchewan, Saskcatoon, SK; [3]Environmental Chemistry, University at Albany-SUNY, Albany, NY; [4]Animal Science, Michigan State University, East Lansing, MI; [5]Civil and Environmental Engineering, Michigan State University, East Lansing, MI. **Analysis of Temporal Trends of Polycyclic Aromatic Hydrocarbon Loadings in Lake Sediments of the Upper Great Lakes Region.**

Previous works on the spatial and temporal distribution of PCB congeners in the upper Great Lakes region indicates during peak PCB concentration loadings (c.1970) the spatial pattern of the relative abundances of PCB congeners were different north and south and distinct in urban areas. Recently (c.2000) north and south patterns are similar, less distinct in urban areas thus reflecting a regional signature. The underlying hypothesis here is that PAH loadings have reduced with emission legislation, evolving to a more well-mixed atmospheric system reflecting a more regional deposition pattern. If true, a spatial pattern similar to PCBs should be observed for PAHs. Sediments from Michigan inland lakes were analyzed temporally for PAH compound concentrations, and inventories and accumulation rates calculated. Further PAH concentrations were compared between c.1970 and c.2000. The corrected inventories and correlating dates of initial appearance of PAHs indicate a spatial gradient increasing from north to south. However, PAH accumulation rates and peak date trends do not follow a regional pattern indicating local watershed influence. Cluster analysis of PAH compounds show an evident spatial pattern change over time. The results are consistent with the hypothesis, but the pattern of PAHs show difference from those of PCBs. *Keywords: Great Lakes basin, PAHs, Spatial analysis.*

ROBINSON, K.D.[1], PIJANOWSKI, B.C.[1], and MILLER, B.K.[2], [1]Department of Forestry and Natural Resources, West Lafayette, IN, 47906; [2]Illinois-Indiana Sea Grant, University of Illinois-UC, Urbana-Champaign, IL, 61801. **User needs assessment: will they come if we build it?**

Throughout the Great Lakes, land use planners are frequently required to consider the potential impacts of land use development on water quality and quantity within their watershed, coastal zone, or nearshore area. Doing so is often viewed as a significant challenge due to the lack of much needed water resource data/information deemed important, but lacking, by planners within the region. In response, we have employed a series of quantitative and qualitative techniques (i.e., surveys, q-sorts, semi-structured interviews, and focus groups) to identify data/information needs and to aid in the development of an online Great Lakes wide decision support tool which will allow land use planners to better evaluate the potential impact of current landscape patterns and future development scenarios both water quality and quantity. Here, we present a number of our research findings ranging from the identification of data/information needs, to current technology use during the planning process, and information and technological capabilities essential to making the Great Lakes wide decision support tool useful for both day-to-day and comprehensive planning processes. We also discuss the perception land use planners hold and how that role affects affects their likelihood of working toward exceeding currently set EPA water quality standards. *Keywords: Land use, Water quality, Policy making, GIS.*

RODENBURG, Z.L.[1], HU, D.[1], HORNBUCKLE, K.C.[1], MA, Y.[2], VENIER, M.[2], and HITES, R.A.[2], [1]Department of Civil & Environmental Engineering, University of Iowa, Iowa City, IA, 52242; [2]School of Public & Environmental Affairs, Indiana University, Bloomington, IN, 47405. **Atmospheric Polychlorinated Biphenyl Congeners and Synthetic Musk Fragrances in Chicago and Lake Michigan.**

Polychlorinated biphenyl (PCB) concentrations in Chicago air near Lake Michigan declined rapidly following the production ban of Aroclors over 30 years ago. However, since the early 1990s, concentrations of these chemicals have decreased only slightly. Synthetic musk fragrances (SMFs), alternatively, are still used in many consumer products, although their atmospheric concentrations in urban and suburban areas are not particularly well-characterized. In order to better understand contemporary atmospheric concentration trends for these chemicals in a large metropolitan area, an extensive passive air sampling network has been established and operating throughout Chicago and along an urban-rural gradient extending beyond its suburbs since December, 2010. Passive samples were collected on polyurethane foam discs (PUF), extracted via Accelerated Solvent Extraction (ASE), then analyzed for 209 PCB congeners (sum of 158 peaks), six polycyclic musks (HHCB, AHTN, DPMI, ATII, ADBI and AHMI) and two nitro musks (musks ketone and xylene) using gas chromatography tandem mass spectrometry (GC/MS/MS). Sample concentration data will be used to determine spatial and temporal variability among sampling sites, identify potential emission sources, and calculate instantaneous chemical fluxes across the air-water interface at Lake Michigan. *Keywords: Chicago, Air-water interfaces, Synthetic fragrances, Chemical analysis, PCBs, Lake michigan.*

ROSS, J.E.[1], MAYER, C.M.[1], TYSON, J.T.[2], and WEIMER, E.J.[2], [1]University of Toledo Lake Erie Center, 6200 Bayshore Rd., Oregon, OH, 43616; [2]Ohio Department of Natural Resources, Sandusky, OH, 44870. **Impacts of Shoreline Alteration on Nearshore Fish Communities: A Reduction in Community Complexity and Habitat Use.**

Across the Great Lakes biodiversity and habitat complexity are greatest within the nearshore zone. In the Ohio waters of Lake Erie nearly 90% of the shoreline has been altered; this number is expected to reach 100% in the near future. The impacts of shoreline alteration on fish communities are poorly understood in the Great Lakes since most fishery assessments focus on offshore zones. Our goal was to quantify the differences in fish species richness and the Habitat Use Index of individual fish species among shorelines with varying levels of shoreline alteration and shoreline substrate. Fish species richness was lower on armored shorelines in wetlands, but not when the background shoreline type was sand or clay. Sites with vegetation always had higher fish species richness. Armoring and vegetation removal also impacted the Habitat Use Index for all fish species. Future management and guidelines for shoreline alteration should take into account the benefits of limiting armoring and increasing vegetative cover in order to further promote fish species richness and species-specific abundance along the shorelines. *Keywords: Lake Erie, Habitats, Fish.*

ROSWELL, C.R.[1], POTHOVEN, S.A.[2], and HÖÖK, T.O.[1], [1]Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN; [2]Great Lakes Environmental Research Laboratory - Lake Michigan Field Station, National Oceanic and Atmospheric Administration, Muskegon, MI. **Patterns of Age-0 Yellow Perch Diets, Growth, and Mortality in Saginaw Bay, Lake Huron.**

Identifying mechanisms influencing early-life survival may elucidate recruitment variability. Yellow perch are economically and ecologically important in Saginaw Bay, Lake Huron, but have recently experienced low recruitment despite strong age-0 production. Recent year classes have been characterized by slow first-year growth, but seasonal growth and accompanying diet and survivorship patterns have not been documented for age-0 perch in Saginaw Bay. To this end, we collected larval and juvenile yellow perch during 2009 and 2010 to track growth and diets during the first year of life. We also evaluated predation and over-winter energy-loss as potential mechanisms of size-selective mortality. Perch growth and energy accumulation slowed during late summer and fall of both years. During larval and juvenile stages, predominant components of yellow perch diets transitioned from copepods to *Daphnia* and other zooplankton; however, we observed only weak ontogenetic shifts toward benthic prey. Smaller perch were preferred by walleye (the main piscivore) and lost substantial energy reserves overwinter, suggesting slow growth of age-0 yellow perch increases mortality risk. Our results are consistent with the hypothesis that recruitment is influenced by interplay of size-selective mortality and diet-induced growth reductions. *Keywords: Recruitment, Diets, Yellow perch.*

ROUS, A.[1], MCLAUGHLIN, R.L.[1], BRAVENER, G.[2], PRATT, T.[3], O'CONNOR, L.[3], BARBER, J.[4], HOLBROOK, C.M.[5], and CASTRO-SANTOS, T.[6], [1]Department of Integrative Biology, University of Guelph, Guelph, ON, N1G 2W1; [2]Sea Lamprey Control Centre, Fisheries and Oceans Canada, Sault Ste Marie, ON, P6A 2E5; [3]Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, Sault Ste Marie, ON, P6A 2E5; [4]Marquette Biological Station, US Fish & Wildlife Service, Marquette, MI, 49855; [5]Hammond Bay Biological Station, US Geological Survey, Millersburg, MI, 49759; [6]Conte Anadromous Fish Research Center, US Geological Survey, Turners Falls, MA, 01376. **Fine-Scale 3D Movements of Sea Lamprey Immediately Downstream of Traps in the St Marys River.**

We examined the movements of invasive sea lamprey (*Petromyzon marinus*) downstream of traps in the St Marys River connecting Lakes Huron and Superior. Invasive animals are a global management concern. Trapping is a valuable form of control. For sea lamprey, increased trapping success in large rivers is desired to meet the management objectives of a binational control program. Previous research demonstrated that trapping efficiency is limited because many sea lamprey do not encounter traps. In 2011 and 2012, we used acoustic telemetry to track 108 sea lamprey approaching traps near the water surface along the wall of the F. H. Clergue Generating Station. 3-D positions were used to test whether low encounter with traps was due to sea lamprey (i) not reaching the power plant wall, (ii) reaching the wall, but aggregating away from traps, or (iii) reaching the wall, but spreading uniformly across the wall away from traps. Contrary to (i), >90% of tagged lampreys entering the hydrophone array made it to the dam face.

Contrary to (ii), and consistent with (iii), sea lamprey activity was spread across the wall both vertically and horizontally, often away from traps. Understanding space use in the vicinity of traps can provide useful insights into behaviours that can influence the success of trapping for control. *Keywords: St. Marys River, Invasive species, Acoustic telemetry, Fish behavior.*

ROUTE, W.T.[1], DYKSTRA, C.R.[2], RASMUSSEN, P.W.[3], KEY, R.[1], and MEYER, M.W.[3], [1]National Park Service, Great Lakes Inventory and Monitoring Network, Ashland, WI, 54806; [2]Raptor Environmental, Susan Springs Drive, West Chester, OH, 45069; [3]Wisconsin Department of Natural Resources, Rhinelander, WI, 54501. **Patterns and Trends in Polybrominated Diphenyl Ethers in Nestling Bald Eagles from Three National Parks in the Upper Midwest.**

Bald eagles serve as good indicators of the health of aquatic systems. We report on patterns and trends in polybrominated diphenyl ethers (PBDEs) in plasma of 267 nestlings sampled between 1995 and 2011 at six study areas in the upper Midwest. Bald eagle productivity averaged >1.0 young per occupied nest for all study areas, which is above the threshold for a healthy population. Eagles nesting on Lake Superior and the upper St Croix watershed had the lowest productivity while those on the Mississippi and lower St. Croix Rivers had the highest. Geometric mean concentrations of PBDEs ranged from a 1.77 *u*g/L in the upper St. Croix watershed to 12.36 *u*g/L on the Mississippi River with Lake Superior nestlings falling in between. Spatial patterns of PBDEs were not correlated with eagle productivity. Our data indicate that total PBDEs (Σ of congeners) increased in nestlings on Lake Superior from 1995 to 2002 and then declined by 5.5% annually from 2007 to 2011, coincident with removal of penta-PBDEs from the market. However, the higher brominated congeners (#153 and #154) increased by about 7.0% annually from 2006 to 2011 in nestlings from the St. Croix watershed and in nestlings along the Mississippi River below the confluence with the St. Croix River.
Keywords: Biomonitoring, PBDE, Lake Superior, Bald eagles, Environmental contaminants, Polybrominated diphenyl ethers.

ROWE, D.C.[1], DONOFRIO, M.C.[1], DIANA, J.S.[2], and HOGLER, S.R.[1], [1]Wisconsin Department of Natural Resources, 2984 Shawano Avenue, Green Bay, WI, 54313-6727; [2]School of Natural Resources and Environment, University of Mcihigan, Ann Arbor, MI, 48109-1041.
Restoration of Muskellunge in Green Bay.

Muskellunge in southern Green Bay were decimated during the early 1900s by habitat destruction, pollution, and over-exploitation. Wisconsin Department of Natural Resources in cooperation with several musky clubs initiated a Great Lakes strain muskellunge reintroduction program in 1989. Rearing of fish began with collection of gametes from the Indian Spread Chain in Michigan and rearing at the Wild Rose Fish Hatchery. Additional spawn was collected from Lake St. Clair and Georgian Bay to increase genetic diversity. Stocking has continued from 1989 through 2010. In 2008, two young-of-the-year (YOY) muskellunge were collected from the Lower Menominee River and in 2009 YOY muskellunge were captured in both the Lower Menominee River and in Sawyer Harbor, Sturgeon Bay. In 2010, the Lake Michigan creel survey estimated 35,342 hours of directed effort for muskellunge on Green Bay and the lower

Fox River, with a yearly catch of 400-2000 fish but a very small harvest of as most anglers practice catch and release. Efforts to develop a self sustaining population have now moved towards understanding the spawning locations throughout the bay, and restoring critical spawning habitat. A spawning model was developed and indicates that the Menominee River is the main critical habitat, and islands in the river are particularly important. *Keywords: Coastal ecosystems, Conservation, Lake Michigan.*

ROWE, M.D.[1], WANG, J.[2], VANDERPLOEG, H.A.[2], ANDERSON, E.J.[2], NALEPA, T.F.[2], LIEBIG, J.R.[2], POTHOVEN, S.A.[2], JOHENGEN, T.H.[3], and FAHNENSTIEL, G.L.[4], [1]NRC Research Associate, NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48108; [2]NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI, 48108; [3]CILER - University of Michigan, 4840 S. State Rd., Ann Arbor, MI, 48108; [4]Michigan Technological University, 1400 Townsend Dr., Houghton, MI, 49931.
Simulating the Direct Impact of Dreissenid Mussel Grazing on Phytoplankton Concentration in Lake Michigan as a Function of Turbulence Parameterization.

The biomass of invasive dreissenid mussels expanded rapidly in Lake Michigan after about 2002, coincident with reduced spring phytoplankton bloom. Previous studies have shown that dreissenid grazing rates can outpace net phytoplankton growth, assuming a well-mixed water column. In addition to the direct impact of grazing, dreissenids alter nutrient cycling. Thus, it is unclear whether disappearance of the spring bloom is due to grazing directly, or due to altered nutrient cycles. We test whether mussel grazing can account for the observed 1998-2010 reduction in spring phytoplankton, in a realistic representation of transport, through application of a novel linked physical-biogeochemical model. We apply the CE-Qual-ICM biogeochemical, lower food web model, forced by a hydrodynamic solution from the Finite-Volume Coastal Ocean Model (FVCOM). Using thermistor and current profiler data from the 1998 EEGLE study, we evaluate the ability of FVCOM to represent vertical gradients in temperature and currents in the offshore and nearshore using two vertical turbulence parameterizations: conventional FVCOM, and with added wind-wave induced vertical mixing. In addition, we present our approach to simulating mussel grazing effects, and preliminary application of the biogeochemical model. *Keywords: Hydrodynamic model, Lake Michigan, Dreissena.*

RUBERG, S.A.[1] and RODGERS, M.[2], [1]4840 S. State Rd, Ann Arbor, MI, 48108; [2]1201 Lakeside Ave, Cleveland, OH, 44114. **Early Warning of Hypoxia Impacts on Water Intakes.**

The Cleveland Water Department (CWD) provides drinking water to approximately 1.5 million people in 72 communities in Northeast Ohio. The water system gets its source water from the Lake Erie Central Basin through four water intakes covering approximately 27 miles of shoreline in the greater Cleveland area. When hypolimnetic waters reach CWD intakes, pre-treatment operations are disrupted and corrosion control strategies are affected by changes in temperature and pH. In addition, a dissolved form of manganese from the hypolimnion enters the distribution system resulting in numerous customer water quality complaints about discolored water. Low oxygen conditions also result in an increase in anaerobic bacteria that contribute high

levels of manganese and iron to the hypolimnion leading to drinking water taste and odor problems. A buoy has been deployed 15 miles north of Cleveland, OH at a depth of 20 meters in the central basin of Lake Erie providing observations of water temperature at one meter intervals, dissolved oxygen, and pH a half meter above the bottom along with currents, waves and meteorological parameters. Real-time information is served to project researchers and CWD drinking water processing managers providing hourly updates of decreasing dissolved oxygen and hypolimnion physical status. *Keywords: Oxygen, Decision making, Waves.*

RUCINSKI, D.K.[1], SCAVIA, D.[2], DEPINTO, J.V.[3], BELETSKY, D.[4], and SCHWAB, D.J.[5], [1]LimnoTech, University of Michigan, Ann Arbor, Mi, 48108; [2]School of Natural Resources and Environment, University of Michigan, Ann Arbor, Mi, 48108; [3]LimnoTech, 501 Avis Dr., Ann Arbor, Mi, 48108; [4]Cooperative Institute for Limnology and Ecosystem Research, University of Michigan, Ann Arbor, Mi, 48108; [5]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, Mi, 48108. **Modeling Hypoxia in Lake Erie: Response to Nutrient Load Reduction.**

A model, calibrated to observations in the Central Basin of Lake Erie, was used to develop response curves relating hypoxia and chlorophyll concentrations to phosphorus loads. The model is driven by a 1D hydrodynamic model that provides temperature and vertical mixing profiles. The biological portion of the coupled hydrodynamic-biological model incorporates phosphorus and carbon loading, internal phosphorus cycling, carbon cycling (in the form of algal biomass and detritus), algal growth and decay, zooplankton grazing, oxygen consumption and production processes, and sediment interactions. Bottom water dissolved oxygen concentrations are predicted over a range of hydrodynamic, climate, and loading scenarios. Hypoxic severity is presented as a modeled function of nutrient inputs from the Western and Central basins of Lake Erie, as well as the Maumee River. *Keywords: Lake Erie, Oxygen, Eutrophication.*

RUDSTAM, L.G.[1], WATKINS, J.M.[1], WEIDEL, B.C.[2], and HOLECK, K.T.[1], [1]Cornell University, 900 Shackelton Point Road, Bridgeport, NY, 13030; [2]USGS-Lake Ontario Biological Station, Oswego, NY, 13126. **Interpreting Acoustic Echograms based on Multifrequency Analysis.**

The information in acoustic data is frequency dependent. This difference can be useful for interpreting the source of the echoes, in particular for separating invertebrates and fish. Such analyses have been used in marine systems for more than a decade even though the complexity of the species assemblage present can make interpretation uncertain. Great Lakes have a simpler pelagic food web without such strong scatterers as wing snails and siphonophores, and the interpretation of echograms is therefore simpler than comparable data from oceans. Even so, the use of acoustics to estimate invertebrate abundance and distribution in the Great Lakes has been limited. We analyzed acoustic data from two frequencies (120 and 430 kHz) collected in Lake Ontario and Lake Superior concurrently with zooplankton net tows. Differences in acoustic return at these two frequencies indicated differences in contributions from large zooplankton such as Limnocalanus, Bythotrephes and Mysis. Through comparisons with net data and predictions from theoretical scattering models, we were able to follow diel migrations of these groups in stationary acoustic data as well as large scale distributions patterns along acoustic transects. *Keywords: Acoustics, Zooplankton, Spatial distribution.*

RUGE, Z.[1], LOHMANN, R.[1], ADELMAN, D.[1], HELM, P.[2], and MUIR, D.C.G.[3], [1]Graduate School of Oceanography, University of Rhode Island, Narragansett, RI, 02882; [2]Ontario Ministry of the Environment, 125 Resources Road, West Wing, Toronto, ON, M9P 3V6; [3]Aquatic Ecosystem Protection Research Division, Environment Canada, 867 Lakeshore Road, Burlington, ON, L7R4A6. **Using Passive Samplers To Detect PBDEs In Lake Superior.**

Passive polyethylene samplers were deployed from April - October 2011 in lower atmosphere and surface water of Lake Superior. A total of ~65 samplers were deployed along the U.S. and Canadian shore and in-lake in paired air-water deployments. The most abundant dissolved BDE congeners were 28, 47, 49, 100 and 99. Highest concentrations were measured for BDE 47 (mean of 0.5 pg/L), followed by Br5 and Br6 congeners. Highest concentrations were measured in the coastal US site Marquette, and the Canadian off-shore stations, with lowest concentrations measured in the open Lake samples. The most abundant BDE congeners in the gas-phase were 47, 100 and 99. Highest concentrations were measured for BDE 47 (mean of 0.7 pg/m3), followed by Br5 and Br6 congeners. Highest concentrations were measured in the coastal US sites, especially Sault St Marie, Ashland and Duluth (sum PBDEs up to 12 pg/m3), while lowest concentrations (sum PBDEs < 1 pg/m3) were obtained for the coastal Canadian and open Lake sites. By using the same sampling matrix (in our case polyethylene, PE) in air and water, activity gradients across the air-water interface were derived. Air-water exchange gradients of the freely dissolved BDE congeners were generally favoring net deposition, and increased with increasing molecular weight of the BDEs. *Keywords: Lake Superior, Atmosphere-lake interaction, PBDEs.*

RUSH, S.A.[1], PATERSON, G.[1], JOHNSON, T.B.[2], STEWART, T.J.[2], DROUILLARD, K.G.[1], HAFFNER, G.D.[1], HEBERT, C.E.[3], ARTS, M.T.[4], MCGOLDRICK, D.J.[4], BACKUS, S.M.[4], LANTRY, B.F.[5], LANTRY, J.R.[6], SCHANER, T.[2], and FISK, A.T.[1], [1]Great Lakes Institute for Environmental Research, University of Windsor, Windsor, On, N9B 3P4; [2]Ontario Ministry of Natural Resources, Glenora Fisheries Station, Picton, On, K0K 2T0; [3]Environment Canada, National Wildlife Research Centre, Ottawa, On, K1A 0H3; [4]Environment Canada, Water Science and Technology Directorate, Burlington, ON, L7R 4A6; [5]United States Geological Survey, Lake Ontario Biological Station, Oswego, NY, 13126-1025; [6]New York State Department of Environmental Conservation, Cape Vincent Fisheries Research Station, Cape Vincent, NY, 13618. **Using fatty acids and stable isotopes to describe the Lake Ontario pelagic food web.**

Chemical and biochemical tracers including the stable isotopes of nitrogen ($\delta^{15}N$) and carbon ($\delta^{13}C$) and dietary fatty acids have become increasingly valuable for understanding habitat and food resource partitioning among aquatic species. In this study, these ecological tracers were used to provide a description of the Lake Ontario offshore food web community including invertebrate, prey fish and top predator specimens. Fatty acid and stable isotope tracer

profiles agreed well with existing knowledge regarding the thermal habitat and food resource preferences for round goby, rainbow smelt, alewife, slimy sculpin and salmonid top predators. The results of this study also suggest that the greatest degree of dietary overlap likely occurs between rainbow smelt and slimy sculpin for *Mysis* prey. For cool-cold water prey species including alewife, rainbow smelt and slimy sculpin, both stable isotope and fatty acid tracers indicated that these species continue to be primarily supported by pelagic production pathways. These results indicate the combination of fatty acid and stable isotopes ecological tracers provide a more powerful, complimentary way of examining food web ecology that cannot be gained with either technique used in isolation. *Keywords: Lake Ontario, Fatty acids, Stable isotopes.*

RUSSELL, A., MOORHEAD, D.L., and CRAIL, T.D., 2801 W. Bancroft St, Mailstop 604, Toledo, Oh, 43606-3390. **The relationship between the round goby and fish communities of Lake Erie tributaries.**

The round goby (Neogobius melanostomus) is a species of fish originating in the Ponto-Caspian region that has invaded the Laurentian Great Lakes. The goby began entering Lake Erie tributaries upon its introduction to the Great Lakes in 1990. Since its introduction, the goby has entered many stream communities but the impact of the round goby on these stream communities is currently unknown. Stream survey data collected by the Ohio Environmental Protection Agency over the last three decades was analyzed in this study to determine relationships between the numbers of round gobies and other fish in these communities. The highest numbers of round gobies occurred with moderate numbers of darters and sunfish, a high number of cyprinids and a low number of suckers. In addition, there was a longitudinal effect with more gobies located in western tributaries near Toledo than eastern tributaries near Cleveland. Most importantly, there was a strong inverse relationship between the number of round gobies and Shannon Diversity of the stream fish community (r-squared value of 0.908, n=170, $p<0.0001$). There was no relationship between gobies and Index of Biological Integrity (IBI) or other physical characteristics of the streams, suggesting that the relationships between gobies and fish communities are largely biological. *Keywords: Round goby, Biodiversity, Fish.*

RUTHERFORD, E.S.[1], VANDERPLOEG, H.A.[1], CAVALETTO, J.[1], LIEBIG, J.R.[1], POTHOVEN, S.A.[1], MASON, D.M.[1], BURNETTE, D.[2], BOURDEAU, P.E.[3], PEACOR, S.D.[3], CLARAMUNT, R.M.[4], BUNNELL, D.B.[5], ROSEMAN, E.F.[5], O'BRIEN, T.P.[5], and WARNER, D.M.[5], [1]4840 S. State Rd, Ann Arbor, MI, 48108; [2]Dana Bldg 1420 Church St, University of Michigan, Ann Arbor, MI, 48109; [3]Dept. Fisheries and WIldlife, Michigan State University, E. Lansing, MI; [4]Michigan DNR Fisheries, Charlevoix Research Station, Charlevoix, MI; [5]USGS GLSC, Green Rd, Ann Arbor, MI. **Consequences of Altered Spatial Structure of Zooplankton for Fish Larvae Growth and Survival in Newly Illuminated Environments of Lake Michigan and Lake Huron.**

Invertebrate invaders may have a negative effect on the recruitment potential of key fish species in Lake Michigan (LM) and Lake Huron (LH) in at least two ways. First, dreissenid mussels have re-engineered nutrient and carbon flows, greatly reduced phytoplankton biomass and increased light transmittance, potentially altering vertical migrations and densities of zooplankton and fish larvae. Second, the density of the visual predator Bythotrephes has increased, creating a potential bottleneck to recruitment through its competition with larval fishes for zooplankton. During 2010-2011 in LM and 2012 in LH, we described spatial distributions of chlorophyll, zooplankton and fish larvae along cross-isobath transects using hydroacoustics, plankton survey system, opening/closing vertical net tows, Tucker trawls, and zooplankton pump. At offshore sites In LM and LH, diurnal samples indicated small zooplankton taxa and most fish larvae were in the metalimnion, whereas large zooplankton exhibited diurnal migration behavior and different spatio-temporal structure than larvae. We discuss the implications of the altered light regime, and spatial distributions and densities of zooplankton on fish larvae diet, growth, survival and potential recruitment. *Keywords: Dreissena, Fish, Recruitment.*

RUTTER, M.A., Penn State Erie, The Behrend College, 4701 College Drive, Erie, PA, 16563.
A Case Study in Applying Bayesian Statistics: Delisting a Great Lakes Area of Concern.

Presque Isle Bay (Erie, PA) was designated the 43rd Great Lakes Area of Concern in January of 1991. One of the beneficial use impairments for Presque Isle Bay is fish Tumors or other deformities, and a multi-year data set for brown bullhead was collected in an attempt to establish delisting targets. In this presentation, I will detail the original proposed statistical methodology and the rational behind the move to a Bayesian approach using a hierarchical logistic regression model. In addition, I will discuss not only the results of the analysis, but also the public's reaction to the use of the results to begin the delisting process for Presque Isle Bay. *Keywords: Area of Concern, Brown Bullhead, Decision making, Bayesian Statistics, Lake Erie.*

SADOWSKY, M.J.[1], CHUN, C.L.[1], OCHSNER, U.[1], BYAPPANAHALLI, M.N.[2], WHITMAN, R.L.[2], PELLER, J.R.[2], TEPP, W.H.[3], LIN, G.[3], and JOHNSON, E.A.[3], [1]BioTechnology Institute, University of Minnesota, St. Paul, MN, 55108; [2]Lake Michigan Ecological Research Station, United States Geolgical Survey, Porter, IN, 46304; [3]Depratment of Bacteriology, University of Wisconsin, Madison, WI, 53706; [4]Department of Soil, Water, and Climate, University of Minnesota, St. Paul, MN, 55108. **Association of Clostridium botulinum with the Macroalga Cladophora in the Great Lakes.**

Avian botulism, a paralytic disease of birds by ingesting neurotoxins produced by *Clostridium botulinum*, often occurs on a yearly cycle and is increasingly becoming more common in the Great Lakes. We hypothesize that C. botulinum grows in the macrophytic alga *Cladophora* spp. and produces toxins which can be subsequently transferred to fish and bird, directly or via other vectors. In this study, free-floating algal mats were collected from shorelines of the Great Lakes between June and October in 2011 and 2012. We quantified the abundance of *C. botulinum* in algal mats and determined the type of botulism neurotoxin (*bont*) genes associated with this organism. In 2011, 39 of 53 algal mats from other shorelines of the Great Lakes contained bont-type E genes and *C. botulinum* was present in up to 15,000 MPN/g dried algae. In addition, bont-type A and B genes which are commonly associated with human diseases were detected in a few algal samples. Mouse toxin assays of the supernatants from enrichment of

Cladophora showed that Cladophora-borne C. botulinum were toxin-producing species. Our results indicate that Cladophora is a habitat for C. botulinum throughout the Great Lakes, warranting additional ecological studies to better understand how this interaction contributes to botulism outbreaks in birds. *Keywords: Algae, Bird, Great Lakes basin, Botulism, Death.*

SALAMOVA, A.[1], PAGANO, J.[2], HOLSEN, T.M.[3], and HITES, R.A.[1], [1]Indiana University, MSB II, room 326, 702 N. Walnut Grove Ave., Bloomington, IN, 47405; [2]Department of Chemistry, State University of New York at Oswego, Oswego, NY, 13126; [3]Department of Civil and Environmental Engineering, Clarkson University, Potsdam, NY, 13699. **Post-1990 Temporal Trends of PCBs and Organochlorine Pesticides in the Atmosphere and in Fish from the Great Lakes Basin are Similar.**

We have analyzed 1990-2010 concentration datasets from the Integrated Atmospheric Deposition Network (IADN) and from the Great Lakes Fish Monitoring and Surveillance Program (GLFMSP) to determine and compare pollutant time trends in the atmosphere and in fish. The analytes of interest were polychlorinated biphenyls, DDTs, chlordanes, dieldrin, and α- and γ-HCHs, and the sites of interest were Lakes Michigan, Erie, and Superior. Overall, we found no statistical differences between the atmospheric and fish temporal trends for any of these compounds in any of the lakes. These results support the conclusion that the atmosphere is the primary source of these compounds to the lakes and that further reduction of the contaminant loads in the fish will require continuing reductions in atmospheric emissions. These results indicate that PCB concentrations are decreasing in both the atmosphere and in the fish with halving times of 13-21 years. The halving times for DDTs, chlordanes, and dieldrin are about 10 years for both the atmosphere and the fish. The most rapid temporal trend was observed for α- and γ-HCH concentrations, which are decreasing in both the atmosphere and in fish with halving times of 3-5 years. *Keywords: Atmosphere-lake interaction, Pesticides, PCBs.*

SAMPLES, A.[1], CLARK, G.[2], DIANA, J.S.[1], GUNN, J.[1], HARRIS, V.[2], JENTES BANICKI, J.[3], LAPORTE, E.[1], ORLANDO, S.[3], PISTIS, C.[1], and QUALLS, T.[2], [1]Michigan Sea Grant, 520 E. Liberty St., Suite 310, Ann Arbor, MI, 48104; [2]Wisconsin Sea Grant, UW-Green Bay MAC 212, 2420 Nicolet Dr., Green Bay, WI, 54311; [3]Ohio Sea Grant, ODNR Office of Coastal Management, 105 West Shoreline Drive, Sandusky, OH, 44870. **Clean Marina Classroom: Online training as an additional vector of education.**

The use of the internet as a medium for educators to reach people across a large geography like the Great Lakes to educate on sustainable practices is examined through the efforts of the Green Marina Education and Outreach Project. Marinas as an industry are key stakeholders that have a significant impact on water quality. Though in person interactions remain vital, the ability to use online training tools as an additional vector of education for marinas increases the potential to protect and enhance water resources. The Clean Marina Classroom provides marina operators with a flexible learning environment and provides program managers a cost-savings through reduced printing and administrative costs. The Classroom was developed through a collaborative process, including representatives from industry, regulatory

and academic sectors. Content is based on the Great Lakes Clean Marina Best Management Practices Guide, which also serves as a suggested standard for Clean Marina program certification requirements. The course is modeled on an online training tool introduced by the Michigan Clean Marina Program in 2009, where as a certification requirement, twelve marinas have completed the course. In developing the regional Classroom, lessons learned pertain to content management and review processes. *Keywords: Great Lakes Restoration Initiative (GLRI), Marinas, Education, Collaboration, Outreach.*

SANDHEINRICH, M.B., BAILEY, S.W., HARO, R.J., ROLFHUS, K.R., and WIENER, J.G., River Studies Center, University of Wisconsin-La Crosse, La Crosse, Wi, 54601.
Methylmercury in Fish in National Parks of the Northwestern Laurentian Great Lakes Region: Potential Risks to Humans and Wildlife.

We conducted a screening-level risk assessment of mercury to populations of game fish, humans that consume fish, and fish-eating birds in six national parks of the northwestern Great Lakes region. Fish were sampled in spring 2008 - 2012 from water bodies in Grand Portage National Monument, Indiana Dunes National Lakeshore, Isle Royale National Park, Pictured Rocks National Lakeshore, Sleeping Bear Dunes National Lakeshore, and Voyageurs National Park. Mercury concentrations in standard-size fish exceeded threshold values for effects on fish health and reproduction in many lakes, indicating that some portion of each fish population was at risk due to methylmercury. Concentrations of methylmercury in filets of some individual game fish in lakes exceeded the USEPA tissue residue criterion of 300 ng/g (parts per billion) wet weight, a criterion established to protect the health of humans who eat noncommercial, wild fish. Mercury in whole prey fish in these parks frequently exceeded 180 ng/g--threshold effects levels associated with reduced reproduction in fish-eating birds. Results indicate that fish populations, humans who eat fish, and piscivorous birds are at risk from methylmercury exposure at a substantive number of locations within these parks and would benefit from reduction in mercury concentrations. *Keywords: Mercury, Risk assessment, Fish.*

SAVAGE, M.L.[1], BOYER, G.L.[1], and WATSON, S.B.[2], [1]Department of Chemistry, State University of New York, College of Environmental Science and Forestry, 1 Forestry Drive, Syracuse, NY, 13210; [2]WHERD Division, Environment Canada, Canadian Centre for Inland Waters, 867 Lakeshore Road, Burlington, ON, L7R 4A6. **Development of Harmful Algal Bloom Indicators for Use in the Great Lakes and Their Application to Lake Neatahwanta, New York.**

Harmful and nuisance algal blooms (HNABs) appear to be increasing in the Great Lakes. Toxic *Microcystis* blooms have occurred in western Lake Erie, Saginaw Bay (Lake Huron), drowned river mouths of Lake Michigan, and in nearshore embayments of Lake Ontario. Recently, the Great Lakes Restoration Initiative has targeted HNAB remediation as a restoration goal. To determine the effectiveness of any remediation actions, indicators are needed to evaluate the extent and severity of HNABs. Key indicators may include parameters such as (a) HNAB toxicity, (b) HNAB species dominance, (c) pelagic HNAB offensive odor or taste, (d) benthic HNAB coverage, (e) benthic HNAB resulting in negative shoreline impacts such as closures, (f) pelagic or benthic HNAB with other harmful effects, and (g) algal bloom extent. Lake Neatahwanta (Fulton, New York) is a small urban lake, with a well-documented history of HNABs, which is currently slated for dredging to reduce nutrient loading. Lake Neatahwanta offers an excellent opportunity to test the effectiveness of such indicators to evaluate remediation efforts. Initial results using the proposed HNAB indicators as applied to Lake Neatahwanta will be presented. *Keywords: Indicators, Nuisance algal blooms, Harmful algal blooms, Lake Neatahwanta, Environmental health.*

SAWTELL, R.W., SAYERS, M.J., SHUCHMAN, R.A., BROOKS, C.N., and JESSEE, N.L., Michigan Tech Research Institute, 3600 Green Ct., Ste. 100, Ann Arbor, MI, 48105. **High Resolution Satellite-Based Water Depth Mapping in the Great Lakes.**

The capability to map water depth using satellite imagery can help fulfill bathymetric mapping needs in nearshore regions, especially where other sources such as LiDAR and sonar have not been able to reach all areas. The ability to accurately map water depth with satellite imagery lessens the need for expensive field work to derive bathymetry. Using high spatial resolution commercial satellite imagery to map depth can provide bathymetry data with accuracies better than one half meter. Several satellite depth mapping methods exist and have been tested to determine their accuracies and limitations in the Sleeping Bear Dunes National Lakeshore (SBDNL) nearshore area. Traditional algorithms required several inputs to calculate depth that may not be readily available or have acceptable accuracy. A new technique has been developed that requires less ancillary input data than existing algorithms by deriving them directly from the image being processed. Accuracies of this new technique, when compared to coastal bathymetric LiDAR, are presented for the SBDNL which primary bottom types consist of sand and submerged aquatic vegetation (SAV). The new technique was also evaluated using several different high-resolution commercial satellite sensors, including WorldView-2 and GeoEye-1. *Keywords: Remote sensing, Nearshore, Bathymetry.*

SAYERS, M.J., RAYMER, Z.B., SHUCHMAN, R.A., FAHNENSTIEL, G.L., and BROOKS, C.N., Michigan Tech Research Institute, 3600 Green Ct., Ste. 100, Ann Arbor, MI, 48105. **Harmful Algal Bloom Mapping for the Great Lakes Using MODIS Satellite Imagery.**

Harmful Algal Blooms (HABs) in the Great Lakes are becoming increasingly problematic as they occur more frequently, in larger areas, and with rising severity. Remote sensing utilizing both satellite and airborne imagery can be effectively used to map and monitor HAB events in the Great Lakes to help decision makers understand the extent of the problem. A satellite-based HAB mapping algorithm has been developed, tested and validated for western Lake Erie where severe HAB events have been occurring. The MODIS-based algorithm has been developed from in situ reflectance measurements and coincident pigment concentration samples that relate the concentrations of the observable, and non-harmful, chlorophyll-a pigment to the blue-green algae pigment, phycocyanin. The algorithm also utilizes ancillary data to help differentiate harmful from non-harmful algal blooms that can occur simultaneously. The decadal time series for Lake Erie has been has been processed producing HAB extent (floating and mixed), onset and offset dates, and areas of possible water quality concern for each cloud free satellite overpass. These results were compared to those derived from a MERIS based HAB mapping algorithm and found good agreement between the two methods. Additionally, clear images of Green Bay and Saginaw bay have been processed and analyzed. *Keywords: Remote sensing, Harmful algal blooms, Climate change.*

SCAVIA, D.[1], CREED, I.F.[2], FRIEDMAN, K.B.[3], KRANTZBERG, G.[4], and LAURENT, K.L.[2], [1]University of Michigan, Ann Arbor, MI, 48104; [2]Western University, London, ON, N6A 5B7; [3]State University of New York at Buffalo, Buffalo, NY, 14260-1100; [4]Mc Master University, Hamilton, ON, L8S 4L8. **Two-axes of analysis that form four potential Great Lakes-St. Lawrence River Basin futures.**

The purpose of the Great Lakes Futures Project is to focus on major issues and uncertainties facing society; imagine the characteristics of alternative futures; and provide a set of policy pathways that move us towards a desirable future within the Great Lakes-St. Lawrence River Basin. A critical phase in this scenario analysis is the investigation of drivers of change within a system and a distillation of those drivers into two main-axes of analysis, which then frame alternate futures for the system. These axes need to be highly influential and highly uncertain forces that are as independent as possible from each other. Following presentations of the key drivers of change within the Basin at a Great Lakes Futures workshop in January at the University of Michigan, participants reviewed, ranked, and proposed sets of alternative axes for consideration. This paper summarizes how the two main axes of analysis: Environmental/Economic Balance and Human Capacity for Change/Governance, were selected for the Great Lakes Futures Project. The intersection of these two axes forms four very different futures, futures that will be explored in the Great Lakes Futures Project and assist in establishing the necessary steps to reach a desired future for the Basin. *Keywords: Great Lakes basin, Drivers of Change, Scenario Analysis.*

SCHAEFFER, J.S., USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105. **Paddling a mile in their shoes- understanding environmental history of Great Lakes Rivermouths.**

Great Lakes Rivermouths represent some of the most altered habitats in the Great Lakes because they are the areas where humans interact most intensely with the lakes. Present conditions reflect clearly a strong trend away from historical ecosystem services in favor of human activities, but there is great misunderstanding about how and why this occurred because people do not pay attention to history. I present historical data that demonstrates that human activities near rivermouths were likely not driven by choices, but rather by economic necessity, and many decisions were based on scientific beliefs that were completely wrong but accepted widely at that time. Furthermore, cultural beliefs about nature and natural resources were vastly different, and in many cases understanding of problems was hindered by communication gaps induced by demographic factors that inhibited knowledge transfer and led to a shifting baseline syndrome. These drivers ultimately led to the current conditions in many port cities. I argue that understanding our environmental history not only illuminates the past, but also provides powerful insights into present day conditions that can help guide modern restoration efforts. *Keywords: Coastal ecosystems, Ecosystem services, Ecosystems, History, Urban areas, Human dimensions.*

SCHLOESSER, J.T.[1], QUINLAN, H.R.[1], and HOFFMAN, J.C.[2], [1]2800 Lakeshore Drive East, Ashland Fish and Wildlife Conservation Office, Ashland, WI, 54806; [2]6201 Congdon Boulevard, U.S. EPA, Mid-continent Ecology Division, Duluth, MN, 55804. **Early Detection of Invasive Fishes in Lake Superior.**

Invasive species pose a serious threat to the Great Lakes warranting continual monitoring for the arrival of new species. Three locations in Lake Superior were identified as "high risk" for new introductions: St. Louis River near Duluth, MN, Upper St. Marys River near Sault Ste. Marie, MI/ON, and Thunder Bay, ON harbor. Sampling occurred during August and September 2010-2012 and was randomly allocated by effective sampling depth for boat electrofishing, fyke nets, and bottom trawling. Annually, 50 stations were sampled at the St. Louis River and 45 stations each at the Upper St. Marys River and Thunder Bay. Analysis indicated a gear mixture of 40% fyke nets, 40% electrofishing, and 20% trawls would maximize the number of species detected at each location. In order to detect 95% of the total estimated species richness, a total of 102, 116, and 90 samples were needed for the St. Louis River, Upper St. Marys River, and Thunder Bay, respectively. We hope to investigate targeted sampling compared to random site selection which has been found to improve sampling efficiency in a case study of the St. Louis River. This evaluation has led to a location specific sampling design for the early detection of a potential new invasive species in Lake Superior. *Keywords: Invasive species, Fish, Lake Superior.*

SCHMIDT, N.C., SCHOCK, N.T., and UZARSKI, D.G., Central Michigan University Biology Department, 217 Brooks Hall, Mount Pleasant, MI, 48859. **Modeling Macroinvertebrate Functional Feeding Group Assemblages in Vegetation Zones of Great Lakes Coastal Wetlands.**

Great Lakes coastal wetlands are important for providing habitat for wildlife, filtration of toxicants, erosion prevention, and for recreation. Macroinvertebrates are sometimes used as a surrogate for ecosystem health but researchers have not developed a model of expected invertebrate community composition throughout successional emergent vegetation zones. We hypothesized that macroinvertebrate functional feeding groups in each zone (*Phragmites*, *Typha*, inner *Schoenoplectus*, outer *Schoenoplectus*, and lily (*Nymphaeaceae*)) can be predicted by organic carbon sources, similar to the River Continuum Concept. We analyzed macroinvertebrate data collected from Great Lakes coastal wetlands from 1997 through 2012. Collectors and predators were the most abundant functional feeding groups across all zones and wetlands, and the presence of grazers decreased along a gradient from shore to open water. Wave exposure, water level fluctuations, and the proximity to streams, as well as productivity and

substrate, were important drivers of macroinvertebrate community composition. We produced a predictive model of macroinvertebrate community composition comparable to the River Continuum Concept that applies to Great Lakes coastal wetlands. *Keywords: Ecosystem modeling, Macroinvertebrates, Wetlands.*

SCHMITT OLABISI, L.[1], CAMERON, L.[2], BLYTHE, S.[1], LEVINE, R.[1], and BEAULAC, M.[3], [1]Michigan State University, Natural Resources Building, East Lansing, MI, 48824; [2]Michigan Department of Community Health, 201 Townsend Street, Lansing, MI, 48913; [3]Michigan Department of Environmental Quality, 525 West Allegan Street, Lansing, MI, 48909.

Participatory Modeling: A Technique for Enhancing Systemic Understanding of Extreme Heat Events and Their Impacts on Human Health.

Supporting adaptation to climate change in the Great Lakes region will require tools that represent the ways in which the components of a human-natural system interact, and that foster dialogue among scientists, decision-makers, and affected populations. Participatory system dynamics modeling promises to accomplish both of these goals. Our multi-disciplinary and multi-institutional research team developed a system dynamics modeling framework, called the Mid-Michigan Heat Model (MMHM), that depicts the dynamics of hospitalizations and deaths over the course of a heat event in Detroit. Throughout the modeling process, local health experts were called upon to co-develop the model structure and comment on the model input and results. While only a prototype, the MMHM was able to facilitate rich dialogue around the problem of extreme heat events in Michigan and their impacts on human health, particularly highlighting the importance of understanding how people behave during these events. Participatory, dynamic models such as the MMHM may be seen as 'tools to think with', and serve an important role in assisting decision-makers with adaptation to climate change. *Keywords: Environmental health, Computer models, Public participation.*

SCHOCK, N.T. and UZARSKI, D.G., Institute for Great Lakes Research, Department of Biology, Central Michigan University, 217 Brooks Hall, Mt. Pleasant, MI, 48859. **Habitat conditions and invertebrate communities of Great Lakes coastal wetlands dominated by Typha spp. and Phragmites australis: implications of macrophyte structure changes.**

Great Lakes coastal wetlands have been lost at an alarming rate (>50%); in some areas this exceeds over 95%. Of the remaining wetlands, habitat fragmentation, degradation and the invasion of exotics has greatly reduced diversity and overall habitat quality of these valuable ecosystems. The recent prolonged period of low water levels in the Great Lakes has increased the expansion of the invasive macrophyte Phragmites australis, which has been directly responsible for the loss of native plant diversity and the displacement of Typha spp. Changes in habitat conditions and biological communities (e.g. fish and invertebrate communities) have been substantial when comparing habitats with different dominant macrophyte types, but specific changes due to a shift from Typha spp. to P. australis dominance has not been explored. We sample 51 Great Lakes coastal wetlands during mid-June to late August in 2010, 2011 and 2012. Habitat condition and macroinvertebrate community data were analyzed to detect annual

variation and differences between habitats dominated by Typha spp. and P. australis. We found that differences in dominant macrophyte structure (i.e. Typha spp. and P. australis) had an impact on habitat conditions and macroinvertebrate community structure.
Keywords: Macroinvertebrates, Wetlands, Coastal ecosystems.

SCHOEN, L.S.[1], HOFFMAN, J.C.[2], SIERSZEN, M.E.[2], STUDENT, J.J.[1], and UZARSKI, D.G.[1], [1]Central Michigan University, Mount Pleasant, MI, 48858; [2]U.S. EPA Mid Continent Ecology Division, Duluth, MN, 55804. **Near Shore-Wetland Fish Movements in the Great Lakes.**

Linkages of Great Lakes coastal wetlands and near shore habitats are under-explored, yet 90 species of fish are known to utilize wetlands for spawning and/or nursery habitat. The duration and frequency of wetland use for pelagic species with mobile adult stages is also poorly understood. We evaluated the utility of otolith microchemistry as a tool for reconstructing habitat use of these species. Since otoliths integrate trace elements from the surrounding water on a daily basis, this microstructural analysis requires trace element gradients between the habitats of interest. Therefore, paired wetland-near shore water samples were collected at 12 sites across Lakes Michigan and Huron. Discrimination between the wetland and near shore sample was determined for 10 of 12 sites using linear discriminant function analysis (LDFA). However, the chemistry of two wetlands could not be distinguished from that of the near shore. This was likely due to wave exposure and pelagic mixing at these fringing wetlands. Multiple response permutation procedure (MRPP) supported this. Our data suggest that otolith microchemistry can be used to estimate fish movements between wetlands and near shore areas of the Great Lake as we analyze yellow perch otoliths to quantify wetland habitat use using the same suite of trace elements. *Keywords: Wetlands, Trace element chemistry, Life history studies, Otolith microchemistry, Mass spectrometry.*

SCHROEDER, B.C.[1], MOFFATT, D.[2], and WATERS, S.[3], [1]Michigan Sea Grant, Michigan State University Extension, 603 South 11th Ave, Alpena, MI, 49707; [2]Northeast Michigan Great Lakes Stewardship Initiative, 500 West Fletcher Street, Alpena, MI, 49707; [3]NOAA Thunder Bay National Marine Sanctuary, 500 W. Fletcher St, Alpena, MI, 49707. **Growing Place-Based Education Opportunities through Community Partnerships: Case Studies from Northeast Michigan.**

The Northeast Michigan Great Lakes Stewardship Initiative fosters place-based education opportunities through school and community partnerships, effectively engaging youth in Great Lakes and natural resource stewardship efforts in northeast Michigan. These partnerships offer a model by which communities and resource management partners can more strategically invest in and benefit from students' environmental learning projects when coordinated with resource management plans, project grants, and community awareness efforts surrounding important resource stewardship issues. In 2012, 29 schools from seven Northeast Michigan counties participated in place-based education programming and professional development activities. Through these activities 72 Northeast Michigan educators were supported in planning and

implementing place-based stewardship education programs and projects with their students. As a result, these school-community partnerships engaged 7,217 youth, through their learning, in fielding youth-led environmental stewardship projects benefiting Northeast Michigan communities. These community partnerships with schools have been key in providing students access to real-world, relevant projects, while supporting schools and teachers with technical expertise, curricula and project resources. *Keywords: Education.*

SCHWEITZER, S.A.[1], COWEN, E.A.[1], HAIRSTON, N.G.[2], SCHAFFNER, L.R.[2], and MILANO, E.[3], [1]DeFrees Hydraulics Laboratory, School of Civil & Environmental Engineering, Cornell University, Ithaca, NY; [2]Department of Ecology & Evolutionary Biology, Cornell University, Ithaca, NY; [3]Department of Biology, Hobart and William Smith Colleges, Geneva, NY. **Baroclinic-Forced Mixing and Transport between a Shallow Shelf and the Main Basin of a Large Deep Lake.**

Cayuga Lake is a long (65km), deep (130m), and narrow (3km) lake in central New York. Its southern end is characterized by a shallow shelf (<6m deep) connected by a steep slope to the main basin. Water residence time and transport on the shelf are controlled by a balance of forces including surface runoff and surface and internal (baroclinic) waves. A field study was conducted to examine the effects of baroclinic forcing on transport within the shelf and exchange with the main basin. Continuous temperature-depth profiles were collected at multiple locations to record the baroclinic motions in the main basin. A detailed spatial and temporal record of the motions of water on the shelf was compiled from thermal and velocity profiles at several locations and 650 CTD casts taken over 11 days. Additionally, zooplankton and phytoplankton samples were collected at regular intervals. We present the results of this study, and show that under typical conditions during the stratified season (i.e., outside of high surface runoff events) baroclinic forcing plays a major part in controlling both the exchange rate between the shelf and the main basin, and transport patterns within the shelf. We demonstrate a connection between these exchange processes and phytoplankton and zooplankton population gradients between the shelf and main lake basin. *Keywords: Hydrodynamics, Baroclinic, Internal waves.*

SEELBACH, P.W., USGS Great Lakes Science Center, 1451 Green Rd, Ann Arbor, MI, 48105. **Reflections on a regional collaboratory.**

The Great Lakes Commission and the US Geological Survey in 2011 co-facilitated the Great Lakes Rivermouths Collaboratory. This was an effort to consider the status and future of rivermouth science, integrating across disciplines and across the large basin geography; and to form an ongoing science and management community around these critical ecosystems. In the past few years, several other environmental collaboratories have been formed in the Great Lakes region (e.g., climate change), and this progressive approach to "doing science" appears destined to spread, due to increasing appreciation of the need for landscape-scale, ecosystems science. In this talk I: 1) review "What is a collaboratory?" ; 2) explore some thinking behind collaborative science; 3) reflect on the successes and limitations of our Rivermouths experience; and 4) posit

some elements for success of future efforts. *Keywords: Regional analysis, Collaboration, Planning, Estuaries.*

SEILHEIMER, T.S.[1] and CHOW-FRASER, P.[2], [1]Wisconsin Sea Grant, 705 Viebahn St, Room F103, Manitowoc, WI, 54220; [2]McMaster University, 1280 Main Street West, Hamilton, ON, L8S 4K1. **Training and Modification of the Wetland Fish Index to Meet User Needs.**

Most effort, time, and money in research projects are dedicated to collecting data, analyzing results, and publishing the findings. While these steps are vital to successful research, there is also, an often overlooked, need to provide training and support for the tools and products derived from research. We developed a wetland fish index to quantify wetland condition based on the fish assemblage. This tool was used by biologists in several National Parks in the Great Lakes to gauge wetland condition and track changes over time. We provided additional support to St. Lawrence Islands National Park by modifying the index to best suit their needs. The support included training on the use of the index, creating an automated spreadsheet for calculating index scores, and the use expert opinion to include new species of local interest to the index. The evolution of tools and availability of authors to provide feedback on published research was vital to the successful use of the wetland fish index. Post-study outreach on new research results and tools is needed to maximize the use of new science for the understanding and improved management of Great Lakes coastal areas. *Keywords: Wetlands, Outreach, Bioindicators.*

SELZER, M.D.[1] and FIELDER, D.G.[2], [1]Michigan Department of Environmental Quality, Office of the Great Lakes, Lansing, MI; [2]Michigan Department of Natural Resources, Alpena Fisheries Research Station, Alpena, MI. **Spawning Reef Restoration in Saginaw Bay, Lake Huron.**

Historically, Saginaw Bay included an inner bay rock reef complex that served as spawning habitat for both spring and fall spawning fishes. That habitat was largely lost over the Twentieth Century due to sedimentation as the watershed transitioned to agriculture. This is believed to have contributed to the collapse of walleye and impacted the local production of other species. Today, walleye are recovered in abundance, but are believed to be dependent almost entirely on river based reproduction and most from a single river resulting in a lack of population resilience. Recently proposed is a demonstration project of reef restoration using a combination of cobble and gravel composed of native rock sources. Two reefs have been identified for restoration known as Coreyon Reef and Saginaw River mouth reef. Envisioned each is a 0.4 ha reef at depths of approximately 1.5-2.2 m. The objectives are to test productive capacity of restored reef habitat and to determine its successional fate in the present day environment. This presentation lays out the rationale for investing in reef restoration, the potential benefits and will detail the proposed evaluation design. Two agencies from the State of Michigan along with Purdue University and others are partnering on this new initiative.
Keywords: Habitats, Fish, Remediation.

SELZER, M.D., 525 W. Allegan St., Lansing, MI, 48909. **A Reflection on Restoration Progress in the Saginaw Bay Watershed.**

The Saginaw Bay watershed remains one of the most diverse watersheds in Michigan, containing America's largest contiguous freshwater coastal wetland system. Its rich resources support a variety of fish and wildlife species, agriculture and recreation opportunities. But today, the region is still in recovery from the stress of rapid population growth. The historic growth in the watershed and on the coastline placed strain on the region's natural resources due to stressors including, excessive nutrient loading, elevated bacteria levels, aquatic habitat loss and persistent toxic contamination. These stressors contributed to declining fish and wildlife populations, loss of coastal wetlands, water quality concerns, beach closings and the buildup of chemicals in the food web. Over the past three decades, extensive federal, state and regional priority-based planning have poised the Saginaw Bay watershed for on-the-ground restoration implementation and research to address these -- mainly legacy -- environmental conditions. This presentation will highlight how investments like the Great Lakes Restoration Initiative and other key funding programs continue to provide the necessary resources and synergy to further advance recovery efforts in a region that deserves our highest attention. *Keywords: Environmental policy, Saginaw Bay, Restoration, Water quality, Great Lakes Restoration Initiative (GLRI).*

SESTERHENN, T.M.[1], ROSWELL, C.R.[1], STEIN, S.R.[1], VERHAMME, E.M.[2], KLAVER, P.[2], POTHOVEN, S.A.[3], and HÖÖK, T.O.[1], [1]Purdue University, Department of Forestry and Natural Resources, West Lafayette, IN, 47907; [2]LimnoTech, Ann Arbor, MI, 48108; [3]NOAA GLERL, Muskegon, MI, 49441. **Implications of multiple hatching sites for larval dynamics in the resurgent Saginaw Bay walleye population.**

The Saginaw Bay walleye population has rebounded impressively following the collapse of alewives, a voracious predator on larval walleye. Consequently, other factors may now limit walleye production in the bay. We sought to assess the implications of successful hatching at geographically disparate locations in Saginaw Bay. We used two models in series to simulate the fate of walleye hatched at four representative locations. Larvae were moved by a particle transport model driven by a hydrodynamics model and grew via individual-based bioenergetics. Model results were then compared to size and age data from larvae collected in Saginaw Bay in 2009-2010. Results suggest that larval growth depends more on hatch date than hatch site. Larvae hatched at any of the sites could be moved nearly anywhere within inner Saginaw Bay by the time they reached a sufficient size to swim independently of water currents, and retention within inner Saginaw Bay was much higher in 2010 than 2009. Our results suggest that the relative importance of the Saginaw River and tributaries as a source of walleye has diminished, with many larvae now likely originating from other locations. Successful hatching at more locations would serve to buffer walleye recruitment variation, arguing for more emphasis on spawning habitat management and restoration. *Keywords: Recruitment, Walleye, Water currents.*

SHAW, J.R., Indiana University, SPEA, 1315 East Tenth Street, Bloomington, IN, 47405.
Population Genomics Reveals Adaptive Variation and a Potential Path to Environmental Forecasting.

In this study, we take advantage of maturing genomic tools for Daphnia to understand the molecular basis for evolved tolerance to certain metals. We also test the adaptive significance of Daphnia's genome structure. Natural populations that have faced severe chemical challenges for over a century of industrial smelting demonstrate evolved tolerance to cadmium. Other reference populations that have no history of chemical stress are clearly harmed by metal exposure, showing slower growth rates, lower fecundity and higher mortality. By measuring the distribution of copy number variants (CNV) and interrogating differential expression of 31,000 annotated genes from sampled populations across chemical conditions and time, this study provides new insights into the functional interactions between genome structure and environment. We identify a large number of CNV (13.5%), including the metal detoxication protein metallothionein that strongly correlate and are predictive of phenotypic differences between populations. Dynamic networks constructed from these CNV reveal functional relationships between genes that are consistent with mechanism of action. These studies begin to quantitatively link genomic variation with individual fitness and population-level outcomes. *Keywords: Genetics, Metals, Ecosystem forecasting.*

SHCHAPOV, K.S.[1], PISLEGINA, E.V.[1], SILOW, E.A.[1], and OZERSKY, T.[2], [1]Irkutsk State University, Institute of Biology, Lenin St. 3, Irkutsk, 664003, Russian Federation; [2]Wellesley College,Department of Biological Sciences, 106 Central St., Wellesley, MA, 02481. **Effect of meteorological and limnological variables on under-ice chlorophyll concentrations in Lake Baikal, Russia: observations from 2010 and 2011.**

The assumption that winter is a time of low biological productivity in lakes that experience seasonal ice cover is increasingly being challenged. Yet, little is known about the dynamics of primary production in winter and the factors that shape under-ice algal biomass. The importance of under-ice primary production in Lake Baikal, Russia has been recognized for decades, but much uncertainty about the drivers of interannual variation in algal biomass remains. In this study we examined the effects of meteorological and limnological conditions on under-ice algal biomass (measured as chlorophyll concentration) during the winters of 2010 and 2011. Our study was carried out in the Southern Basin of Lake Baikal. Meteorological data were obtained from a shore-based automatic meteorological station. Limnological data and chlorophyll measurements were collected every two weeks at depths of 0, 5, 10, 25, 50, 100, 150, 200, 250 m at a long-term monitoring station approximately 2.5 km offshore. Variation in chlorophyll concentration was examined in relation to solar radiation, summer temperatures, and water clarity. Preliminary results suggest that light availability and heat content of the water have important effects on under-ice phytoplankton biomass in Lake Baikal. *Keywords: Atmosphere-lake interaction, Phytoplankton, Ice.*

SHEN, C.[1], LIAO, Q.[1], TROY, C.D.[2], and BOOTSMA, H.A.[3], [1]Department of Civil Engineering and Mechanics, University of Wisconsin - Milwaukee, Milwaukee, WI, 53211; [2]School of Civil Engineering, Purdue University, West Lafayette, IN, 47907; [3]School of Freshwater Sciences, University of Wisconsin - Milwaukee, Milwaukee, WI, 53211. **One dimensional turbulent mixing model in Lake Michigan with non-breaking wave induced mixing.**

The conventional Mellor-Yamada level 2.5 turbulence closure (MY2.5) has been one of the most successful vertical mixing model for studies in ocean hydrodynamics and turbulent mixing characteristics. We have applied MY2.5 with a one-dimensional modeling framework to simulate the vertical profiles of temperature and turbulence characteristic in Lake Michigan. The simulation results were not satisfactory as the temperature profile differed significantly from the measure one, especially during the summer time. We found that wave-turbulence interaction should be included in the model to better reproduce the mixing process in the mixed layer. In this study, two equations of the 1-D, MY2.5 closure scheme was modified by introducing a non-breaking wave induced vertical diffusivity (Bv) and a new parameterization of turbulent kinetic energy dissipation rate (εw) induced by wave-turbulence interaction. With the modified model, the numerically simulated surface water temperature of Lake Michigan matched much better with the measured derived from the satellite data in 2012. The result shows significant impact of wave-turbulence interaction on wave induced mixing. Moreover, wave effects on structures of the mixed layer and the distribution of turbulence were also investigated and discussed.
Keywords: Lake Michigan, Wave-turbulence interaction, Waves, Turbulent mixing, Model studies.

SHERMAN, J.S. and UZARSKI, D.G., Central Michigan University, Institute for Great Lakes Research, Mount Pleasant, MI, 48859. **Comparing biotic assemblages and abiotic conditions in diked and adjacent open wetlands: a case study in Erie Marsh Preserve.**

The goal of the Great Lakes Instrumentation Collaboratory: Implementing Great Lakes Coastal Wetland Monitoring project is to develop a monitoring program for evaluating the status and trends of Great Lakes coastal wetland health throughout the basin for protection and restoration of these systems. This project surveyed benchmark sites as well as randomly selected wetlands to help agencies identify potential sites for restoration and protection projects. Here we provide a case-study of a restoration project in North Maumee Bay, Lake Erie. The Erie Marsh Preserve, a 990 acre diked marsh, is being restored to its natural hydrologic regime and connectivity to the lake. We surveyed and compared macroinvertebrate and fish assemblages as well as chemical and physical characteristics from habitats inside and outside the dike in 2011 and 2012. Species richness, Shannon Diversity, and Hurlburt's PIE were calculated using rarefied numbers to represent species assemblages. Community richness, diversity, and evenness inside of the dike differed from communities outside of the dike both years. Principal components analysis revealed differences in habitat characteristics between the diked and undiked wetland suggesting that restoration of the hydrologic regime could increase diversity and richness in the area. *Keywords: Diversity, Coastal wetlands, Management.*

SHOEIB, M.[1], JANTUNEN, L.[2], and HUNG, H.[1], [1]Environment Canada, 4905 Dufferin Street, Toronto, ON, M3H 5T4; [2]Environment Canada, 76248 Eighth Line, Ebgert, ON, L0L 1N0.
Legacy and Current Use Flame Retardants in the Great Lakes Atmosphere.

Flame retardants (FRs) are used in a wide variety of products and applications. Polybrominated diphenyl ethers (BDEs) have been the most studied FRs over the past two decades. The phase out of PentaBDE and OctaBDE formulations in North America and Europe has led to the increased use of alternate FRs (non-BDEs) to meet flammability standards for different products. Organophosphate esters (OPs), in particular triesters, are high-production-volume chemicals used also as FRs and plasticizers to protect or to enhance the properties of plastics, textiles, furniture and many other materials. Occurrences of BDEs, non-BDEs and OPs FRs in the biota and environmental media in remote regions suggest that FRs are subject to long-range transport. The objectives of this study are to measure the level of FRs in the Great Lakes atmosphere and to determine gas-particle partitioning of several classes of non-BDEs and OPs FRs. Air samples were collected over lakes Ontario, Superior and Huron between 2008-2012. Highest concentrations were seen over Lake Ontario, followed by Lake Huron and the lowest were seen over Lake Superior. Urban centres were also found to be a source of both BFRs and OPs. *Keywords: Pollutants, Particle-gas distribution, PBTs, Flame retardants, Environmental contaminants, Organophosphates.*

SHUCHMAN, R.A.[1], SAYERS, M.J.[1], LESHKEVICH, G.[2], JOHENGEN, T.H.[3], BROOKS, C.N.[1], and POZDNYAKOV, D.[4], [1]Michigan Tech Research Institute, 3600 Green Ct., Ste. 100, Ann Arbor, MI, 48105; [2]NOAA-GLERL, 4840 S. State St, Ann Arbor, MI, 48108; [3]3Cooperative Institute for Limnology and Ecosystems Research, University of Michigan, Ann Arbor, MI, 48108; [4]4Nansen International Environmental and Remote Sensing Centre, 14th Line Street 7, office 49; Business Centre "Preobrazhensky" Vasilievsky Island, St. Petersburg, 199034, Russia. **An Algorithm to Retrieve Chlorophyll, Dissolved Organic Carbon, and Suspended Minerals from Great Lakes Satellite Data.**

An algorithm has been developed for the Great Lakes that utilizes SeaWiFS, MODIS, or MERIS satellite data to estimate concentrations of Chlorophyll (chl), dissolved organic carbon (doc), and suspended minerals (sm). The Color Producing Agent Algorithm (CPA-A) utilizes a specific, updated hydro-optical (HO) model for each lake. The HO models provide absorption functions for all three CPAs (chl, colored dissolved organic matter (cdom), and sm) as well as backscatter relationships for chl and sm, and were generated using simultaneous near surface optical data collected with in situ water chemistry measurements during research cruises in the Great lakes. A single average HO model for the Great Lakes was found to generate insufficiently accurate retrievals for Lakes Michigan, Erie, Superior and Huron. The new HO models were then evaluated with respect to EPA in situ observations, as well as compared to the NASA OC3 retrieval. The CPA-A retrievals provided more accurate chl values for Lakes Michigan, Superior, Huron, and Ontario than those from the NASA approach as well as providing concentrations of doc and sm. The CPA-A chl retrieval for Lake Erie is quite robust, producing reliable chl values within EPA concentration ranges, while the NASA chl retrieval for this case II water provided

chl estimates with large uncertainty. *Keywords: Remote sensing, Chlorophyll, Dissolved organic matter.*

SICOLY, L.L.[1], MCLAUGHLIN, R.L.[1], WILSON, C.C.[2], MACKERETH, R.W.[3], and NICHOLS, K.[4], [1]Department of Integrative Biology, University of Guelph, Guelph, ON; [2]Aquatic Biodiversity and Conservation Unit, Ontario Ministry of Natural Resources, Trent University, Peterborough, ON; [3]Centre for Northern Forest Ecosystem Research, Ontario Ministry on Natural Resources, Thunder Bay, ON; [4]National Marine Fisheries Service, Northwest Fisheries Science Center, Conservation Biology Division, Seattle, WA. **Behavioural and Genetic Diversity Among Ecotypes of Lake Superior Brook Trout (Salvelinus fontinalis).**

We used crosses between migrant and stream resident brook trout caught from tributaries along the north shore of Lake Superior to test for genetic variation in behavioural traits believed to be tied to migratory behaviour, including risk taking, general activity, and sociability. Two ecotypes of brook trout (Salvelius fontinalis) originate from tributaries in this part of Lake Superior: a large ecotype that migrates to lake and a small ecotype that remains stream resident. The abundance and distribution of the migrant ecotype has declined in range and abundance, and is the focus of conservation concern. In 2011, migrant and non-migrant adult brook trout were captured in the field and crossed to generate 26 families. In spring and summer of 2012, ten fish from each of family were put through three behavioral experiments to assess risk taking, activity, and sociability. Results of these tests will be used to test for quantitative genetic variation in the behavioural measures made in the lab. This research will help understand whether the life history variation observed among brook trout populations in Lake Superior is due to genetic polymorphism or phenotypic plasticity, and will assist managers with efforts to conserve and restore these populations. *Keywords: Trout, Fish behavior, Lake Superior.*

SIERACKI, J.L. and BOSSENBROEK, J.M., University of Toledo, 2801 W. Bancroft St., Toledo, OH, 43606. **Predicting the Secondary Spread of Invasive Species by Commercial Ship Ballast Water Using a Dynamic Spatial Model.**

To predict the spread of invasive species in the Laurentian Great Lakes due to ballast water, we built a dynamic spatial model that uses ballast information to establish the pattern of species movement. Three models were built and tested to identify the ballast data that would best fit the past spread of Eurasian ruffe (*Gymnocephalus cernuus*) and zebra mussel (*Dreissena polymorpha*). The "random model" had no ballast information and selected new occurrences randomly within the Great Lakes. The "location model" selected new occurrences randomly from known ballast discharge locations. The "propagule pressure" model selected new occurrences from known ballast discharge locations that were weighted by the ship visits and species' survival rates in the ballast tank. Two other parameters were used in all models, an initial spread distance, which identified the area of initial infestation, and a natural spread distance, which was a species-specific distance applied each year modeled. Since zebra mussels became widespread rapidly in the Great Lakes, only 1986 to 1992 were simulated. Ruffe were modeled from 1986 to

2011 since they are still not widespread. The best fit model was used to predict the future spread of ruffe, golden mussel (*Limnoperna fortunei*), and killer shrimp (*Dikerogammarus villosus*).
Keywords: Ballast, Spatial modelling, Invasive species, Risk assessment.

SIERSMA, H.M.H.[1], FOLEY, C.J.[2], NOWICKI, C.J.[1], QIAN, S.S.[3], and KASHIAN, D.R.[1], [1]Wayne State University, Department of Biological Sciences, Detroit, MI, 48201; [2]Illinois-Indiana Sea Grant, Purdue University, West Lafayette, IN, 47907; [3]The University of Toledo, Department of Environmental Sciences, Toldeo, OH, 43606. **Trends in the Distribution and Abundance of *Hexagenia spp.* in Saginaw Bay, Lake Huron, 1954-2012: Moving Towards Recovery?**

Benthic habitats and biota of the Laurentian Great Lakes have been detrimentally impacted by multiple disturbances related to agriculture, industry, and other human activities. One effect of these stressors has been the extirpation of the environmentally sensitive burrowing mayfly genus, *Hexagenia*, from some shallow embayments. Recently, local residents have reported *Hexagenia* swarms near Saginaw Bay, Lake Huron; however, benthic bay surveys in the last 50 years have discovered only an occasional *Hexagenia* nymph. Therefore, we evaluated the current status of *Hexagenia* in Saginaw Bay. Adult *Hexagenia* populations were quantified, during 2010 mayfly emergence events at three sites in Tawas, Michigan, USA, at densities of >170 *Hexagenia*/m^2/site. Nymphal populations were quantified, from Ponar grab samples collected at 57 bay locations between 2009 and 2012, at an average density of 1.5 nymphs/m^2 and at 15.8% of sampled locations. This is the greatest documented distribution of *Hexagenia* nymphs found in the bay since 1956. The confirmation of a nearby adult population and the occurrence of nymphs in the bay potentially indicate the beginning of a *Hexagenia* return to Saginaw Bay and, therefore, a possible improvement of its ecosystem health and integrity.
Keywords: Ecosystem health, Mayfly, Biomonitoring, Recovery, Spatial distribution, Benthic degradation.

SIERSZEN, M.E.[1], STOCKWELL, J.D.[2], HRABIK, T.R.[3], COTTER, A.M.[1], HOFFMAN, J.C.[1], and YULE, D.L.[4], [1]USEPA, 6201 Congdon Blvd, Duluth, MN, 55804; [2]University of Vermont, 3 College St., Burlington, VT, 05401; [3]University of Minnesota-Duluth, 1035 Kirby Dr, Duluth, MN, 55812; [4]USGS, 2800 Lakeshore Dr East, Ashland, WI, 54806. **Depth gradients in food web processes linking Lake Superior habitats.**

The Lake Superior fish community is structured by depth, with nearshore and intermediate-depth species giving way to a deepwater community. There is also a nearshore-offshore gradient in the importance of benthic resources to forage fishes. This gradient appears to be structured by declines in the abundance of benthos with depth, and a concurrent increase in diel vertical migration by biota to exploit planktonic production. Top predators (lean and siscowet lake trout) follow a different pattern, with nearshore leans more strongly linked to pelagic food web pathways than the deepwater siscowets. These linkages may be important to maintain or re-establish among habitats as a part of restoration efforts across the Great Lakes.
Keywords: Food chains, Lake Superior, Stable isotopes.

SILVA, M.R.[1], BRAVO, H.R.[1], CHERKAUER, D.[2], KLUMP, J.V.[3], KEAN, W.[2], and MCLELLAN, S.L.[3], [1]1Department of Civil Engineering and Mechanics, University of Wisconsin-Milwaukee, 3200 N. Cramer St., Milwaukee, WI, 53201; [2]2Department of Geosciences, University of Wisconsin-Milwaukee, 2200 E. Kenwood Blvd., Milwaukee, WI, 53201; [3]School of Freshwater Sciences - Great Lakes WATER Institute, University of Wisconsin-Milwaukee, 600 E. Greenfield Ave., Milwaukee, WI, 53204. **Effect of Hydrological and Geophysical Factors on Formation of Standing Water and Fecal Indicator Bacteria Reservoirs at a Lake Michigan Beach.**

The deterioration of Great Lakes beaches is caused by a number of factors including fecal pollution from point and non-point sources, erosion due to wind or wave action, invasive vegetation and chronically wet, flooded or standing water conditions. We investigated the hydrological and geophysical characteristics of the Bradford Beach on Lake Michigan (Milwaukee, WI) and the linkage between standing water and persistent contamination by fecal indicator bacteria (FIB). Our study showed that there is a significant positive correlation between high concentrations of *Escherichia coli* (*E. coli*) in sand and chronic high moisture content caused by standing water. Overall, the main factor influencing the formation of standing water was rainfall. Notable differences in standing water and/or wet sand conditions in the northern and southern parts of the beach could be accounted for by differences in ground water elevations and beach erosion and accretion patterns. Standing water was a health concern, especially during heavy rainfall events when rain gardens overflowed and wave run-up delivered contaminated water to the backshore of the beach. *Keywords: Lake Michigan, Water quality, Hydrologic cycle.*

SLAWECKI, T.A.D.[1], RUBERG, S.A.[2], and READ, J.G.[3], [1]LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108; [2]NOAA/GLERL, 4840 S. State Rd, Ann Arbor, MI, 48108; [3]GLOS, 229 Nickels Arcade, Ann Arbor, MI, 48104. **Identifying Regional Data Management and Decision Support Tools: Process and Outcomes.**

The National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Laboratory (NOAA/GLERL) committed funding in 2012 to expand the development of data management and decision support tools consistent with the recommendations of the 2011 Great Lakes Observing System (GLOS) Enterprise Architecture (EA). The project goal was to support the identification, design and development of data management infrastructure and decision support products that (1) advance the implementation of the GLOS enterprise as laid out in the GLOS EA report and the GLOS Mission and (2) are responsive to user needs. These data management and decision support elements were targeted to address issues at the regional scale while addressing priority goals of the Great Lakes Restoration Initiative. In the course of the project, targeted interviews, online surveys, five regional webinars and two "all-hands" gatherings were used to elicit and refine user needs and concepts for tools to address these needs. Our IAGLR presentation will review the process and present the outcome of the project: specific recommendations for different tool concepts identified as important, and general findings about the nature and sustainability of decision support tools. *Keywords: Observing systems, Stakeholder, Decision making, Data storage and retrieval.*

SLOAN, C.M.[1], REED, A.J.[1], SADOWSKY, M.J.[2], and HICKS, R.E.[1], [1]Department of Biology, University of Minnesota Duluth, SSB 207, 1035 Kirby Drive, Duluth, MN, 55812; [2]Department of Soil, Water and Climate, University of Minnesota, 258 Borlaug Hall, 1991 Upper Buford Circle, St. Paul, MN, 55108. **Antibiotic and Heavy Metal Resistant Bacteria from Ballast Water Discharged into the Duluth-Superior Harbor.**

Invasive bacteria may alter native bacterial communities by transferring genetic material that encodes for resistance to antibiotics and heavy metals. The abundance of antibiotic and heavy metal resistance genes was characterized for ballast water collected from ships actively discharging ballast into the Duluth-Superior Harbor during 2011 and 2012. Four fosmid libraries containing metagenomic DNA of bacteria filtered from ballast water samples and the Duluth-Superior Harbor water were created. The fosmid libraries were screened for antibiotic resistance to cefotaxime, benzylpenicillin and levofloxacin and heavy metal resistance to silver, cadmium, zinc and mercury. The minimum inhibitory concentration was established for each fosmid library for the chosen antibiotics and heavy metals to determine the level of resistance by bacteria in each water sample. *Keywords: Ballast, Bacteria, Resistant.*

SMITH, D.L., COOPER, M.J., KOSIARA, J.M., and LAMBERTI, G.A., Department of Biological Sciences, University of Notre Dame, Notre Dame, IN, 46556. **Heavy Metal Contamination in Lake Michigan Wetland Turtles.**

The presence and effects of heavy metal contaminants have been explored in some Great Lakes coastal wetlands. However, turtles have been neglected in contaminant analyses, although they are common in many contaminated wetlands. We sampled turtles from known areas of contamination to determine if turtles could be used as indicators of heavy metal contamination. We also examined non-lethal versus lethal sampling techniques for heavy metal analyses. We measured arsenic, cadmium, chromium, copper, lead, and zinc in common snapping (Chelydra serpentine), painted (Chrysemys picta), musk (Sternotherus odoratus), and map (Grapetemys geographica) turtles collected from four Lake Michigan wetlands with differing levels of contamination. Non-lethal samples (claws and shell scrapings) were collected from all turtles and a subset of whole turtles was collected for muscle and liver tissue analysis. If non-lethal sampling methods prove adequate, surveillance for heavy metal contamination via turtles could be added to routine wetland monitoring programs. Additionally, common snapping turtles are often harvested for human consumption in the Lake Michigan area, making turtle contaminant levels important to the wellbeing of many fishermen and their families. *Keywords: Coastal wetlands, Turtles, Lake Michigan.*

SMITH, D.R., LIVINGSTON, S.J., HEATHMAN, G.C., and HUANG, C., 275 S. Russell St., West Lafayette, IN, 47906. **Phosphorus Loading to Lake Erie from Agriculture - Lessons from the St. Joseph River Watershed Conservation Effects Assessment Project (CEAP) in Indiana.**

Conservation tillage has led to a decrease in the total P (TP) loading to the Western Lake Erie Basin (WLEB). However, soluble P (SP) loading has increased recently, leading to harmful and nuisance algal blooms (HNABs). Some have suggested P stratification with conservation tillage is the cause of increased SP loading to WLEB. The Conservation Effects Assessment Project (CEAP) has been monitoring the St. Joseph River Watershed in northeast Indiana since 2002. This presentation will serve as a discussion of the culprits for P loading observed through the CEAP project. Monitoring of surface runoff and subsurface tile flow from fields has led to the discovery that roughly 50% of the TP and SP leaving the fields occurs through subsurface tile. The ratio of SP to TP is greater from no-till fields than tilled fields; however, the total amount of P loading from tilled fields is much greater. Tile risers are hydrologic shunts, transporting nutrient rich water from distal areas within a watershed directly to the stream network. A short planting window in the region, leads to a reluctance of farmers to apply fertilizers at planting. Applications of fertilizers or manures during the winter (i.e. on frozen or snow covered ground) have been common. Commercial fertilizers are very soluble (>90%) and are applied at times when the pote *Keywords: Lake Erie, Phosphorus, Watersheds.*

SMITH, J.P., Cooperative Institute for Limnology and Ecosystems Research - University of Michigan, 4840 S. State Rd, Ann Arbor, MI, 48108. **Web-based Interactive Data Visualization Using The Dygraphs JavaScript Visualization Library.**

For scientific investigations and projects, data visualizations can help describe project results. However, oftentimes data visualizations are non-interactive illustrations of data. Adding elements of interactivity within data visualizations may improve target audience's understanding of investigations or projects from which visualized data originates. Using Laurentian Great Lakes water level data and a free, open source Dygraphs JavaScript visualization library, this presentation demonstrates a method of data visualization for the web with comma delimited formatted data. *Keywords: Data acquisition, Visualization, Data storage and retrieval, Communication.*

SMITH, J.R.[1], KOMINOWSKI, A.L.[1], and SPARKS, D.[2], [1]Indiana Department Environmental Management _OLQ/OLC, 100 N. Senate Ave - N1307, Indianapolis, IN, 46204-2251; [2]U.S. Fish & Wildlife Service - BFO, 620 South Walker Street, Bloomington, IN, 47403-2121. **Use of Natural Resource Damages Assessment and Great Lakes Legacy Act for Removal of Beneficial Use Impairments in Grand Calumet River Area of Concern, Lake County, Indiana.**

Through environmental enforcement actions and Natural Resource Damage Assessment (NRDA) settlements, the Indiana Natural Resource Trustees (Indiana Department Environmental

Management, Indiana Department Natural Resources and U.S. Fish and Wildlife Service) and Indiana Department of Environmental Management have leveraged approximately $77 Million for restoration and remediation of the Grand Calumet River Area of Concern (AOC). Matching Great Lakes Legacy Act (GLLA) funds provided by U.S. Environmental Protection Agency Great Lakes National Program Office has resulted in over 2 miles of river dredging and capping, 30 acres of habitat restoration and in-place agreements to remediate and restore another 2.2 miles of river and over 80 acres of riverine wetlands. These efforts will eventually aid in the removal of 9 of 12 remaining impaired beneficial uses in the AOC. This presentation will discuss activities associated with integration of NRD and GLLA funding to facilitate eventual delisting of the AOC. *Keywords: Sediments, NRDA, Wetlands, GLLA, Remediation, AOC.*

SMITH, S.D.P.[1], ALLAN, J.D.[1], HALPERN, B.S.[2], MCINTYRE, P.B.[3], BOYER, G.L.[4], BUCHSBAUM, A.[5], BURTON, G.A.[1], CAMPBELL, L.M.[6], CHADDERTON, W.L.[7], CIBOROWSKI, J.J.H.[8], DORAN, P.J.[9], EDER, T.[10], INFANTE, D.M.[11], JOHNSON, L.B.[12], MARINO, A.L.[1], READ, J.G.[1], ROSE, J.B.[11], RUTHERFORD, E.S.[13], SOWA, S.P.[9], and STEINMAN, A.D.[14], [1]Univ. of Michigan, Ann Arbor, MI, 48109; [2]National Center for Ecological Analysis and Synthesis, Univ. of California, Santa Barbara, CA, 93101; [3]Center for Limnology, Univ. of Wisconsin, Madison, WI, 53706; [4]State Univ. of New York, Syracuse, NY, 13210; [5]National Wildlife Federation, Ann Arbor, MI, 48104; [6]St. Mary's Univ., Halifax, NS, B3H 3C3; [7]The Nature Conservancy c/o Notre Dame Environmental Change Initiative, South Bend, IN, 46617; [8]Univ. of Windsor, Windsor, ON, N9B 3P4; [9]The Nature Conservancy, Lansing, MI, 48906; [10]Great Lakes Commission, Ann Arbor, MI, 48104; [11]Michigan State Univ., East Lansing, MI, 48824; [12]Natural Resources Research Institute, Univ. of Minnesota, Duluth, MN, 55811; [13]Great Lakes Environmental Research Laboratory, National Oceanic and Atmospheric Administration, Ann Arbor, MI, 48108; [14]Annis Water Resources Institute, Grand Valley State Univ., Muskegon, MI, 49441. **Using Expert Judgment to Quantify the Relative Impacts of 50 Environmental Stressors in the Laurentian Great Lakes.**

The Great Lakes Environmental Assessment and Mapping project (GLEAM) aims to map cumulative stress in the Great Lakes by synthesizing the spatial distributions of a broad suite of environmental stressors (e.g., various invasive species, pollutants, coastal development). We have used expert judgment throughout this synthesis project, particularly in the development of weightings to represent the relative impacts of stressors. In an online survey, we asked researchers, NGO members, and natural resource managers to rate the impact of each stressor in different habitats, focusing on five components of impact (spatial extent, temporal frequency, ecological scope, magnitude of change, and recovery time). Some invasive species (e.g., mussels and ballast invasion risk), climate change, and phosphorus loading were rated as having the greatest current impacts. There was only low variation in ratings by lake and ecosystem zone, but some variation among respondents. For example, researchers emphasized nonpoint pollutants and climate change more than did managers. This survey provides a basin-wide, quantitative summary of expert opinion on the impacts of stressors, contributing new information for prioritizing restoration. In future work, we may use surveys to quantify restorability of stressors and interactive effects between stressors. *Keywords: Environmental effects, Ecosystems, Spatial analysis.*

SNIDER, M.J. and BIDDANDA, B.A., Grand Valley State University, 740 W. Shoreline Dr., Muskegon, MI, 49441. **Probing the Pigments and Physiology of Cyanobacterial Mats that are Modern Analogs of Life on Early Earth.**

Recently discovered submerged sinkholes in Lake Huron are low-oxygen, high-sulfur extreme environments for microbial life. These habitats mimic conditions on Earth's early shallow seas and could improve our understanding of deep Earth history. My work investigates the pigments and photophysiology of the cyanobacteria dominated mats present in these sinkholes under in situ and laboratory studies to understand how they adapt to variable light quality and intensity. Mats were grown in varying light intensities and photosynthetic inhibitors and examined for changes in pigment composition and photosynthetic efficiency using PAM fluorescence to gain insight into the light adaptive capabilities and use of oxygenic and anoxygenic photosynthesis. In situ observations show marked seasonality in photosynthetic efficiency for all sites during the growing season (from 41-70%). Lab results indicate a 1 - 2 day photoacclimation period after which yield stabilizes and increased light intensity treatments result in increased efficiency. Inhibitor studies reveal that DCMU, a photosystem II inhibitor, significantly halted photosystem II activity, while NaH2S had no effect. Further observations will reveal whether variable pigment composition reflect photophysiology and functional diversity in these novel Great Lakes ecosystems. *Keywords: Photosynthesis, Microbial mat, Microbiological studies, Photosynthetic pigments, Benthos, Pulse Amplitude Modulation.*

SNYDER, A.R., Indiana Department of Environmental Management Northwest Regional Office, 8380 Louisiana Street, Merrillville, IN, 46410. **Habitat Restoration Planning in the Grand Calumet River Area of Concern.**

In 2012 the US EPA tasked the Great Lakes Areas of Concern with drafting updated Remedial Action Plans, for the Grand Calumet River Area of Concern this involved significant planning and updates to the removal criteria for the Loss of Fish and Wildlife Habitat Beneficial Use Impairment. Potential habitat restoration sites were categorized based on a three-tiered approach where properties that have the highest potential to meet the Floristic Quality Index and Quality Habitat Evaluation Index standards were designed as Tier one projects. The connectivity, acreage, and impacted species of these properties were reviewed along with determinations on whom and how the restoration could take place. The sum of the acreage deemed appropriate totaled 964 acres of dune and swale habitat, but in an effort to make the removal of this BUI more tangible a 90% completion goal was set. The final outcome produced an updated Remedial Action Plan that requires restoration of 867 acres of dune and swale habitat for Karner Blue Butterfly, Blandings Turtle, Spotted Turtle and various migratory birds. *Keywords: Habitats, Restoration, Management, Decision making.*

SNYDER, R.J.[1], BURLAKOVA, L.E.[2], KARATAYEV, A.Y.[2], and MACNEILL, D.B.[3], [1]Biology Dept., SUNY Buffalo State, 1300 Elmwood Ave., Buffalo, NY, 14222; [2]Great Lakes Center, SUNY Buffalo State, 1300 Elmwood Ave., Buffalo, NY, 14222; [3]New York Sea Grant Extension, SUNY Oswego, Oswego, NY, 13126. **Enhanced Early Detection of Invasive Ponto-Caspian Fishes in the Great Lakes.**

The rich biota of the Ponto-Caspian region coupled with a high volume of commercial shipping traffic strongly suggests that this region will continue to be a major source of invasive fishes to the Great Lakes. In this study we use a variety of sources of information (primarily European literature available in English and Russian) to more accurately assess current fine-scale geographic distributions and "propagule pressure" in European shipping ports associated with high-risk Ponto-Caspian fishes. We also review published and unpublished reports to assess aquatic habitats in and around Great Lakes ports to identify specific locations that provide a strong habitat match for these high-risk invasive fishes at various life history stages. This information is then used to identify critical time periods and spatial "hot spots" in and around Great Lakes ports that should be included in future surveillance and early detection efforts. *Keywords: Invasive species, Ponto-Caspian basin, Monitoring.*

SORENSEN, L.S.[1], WILSON, J.[2], and WILKIE, M.P.[1], [1]75 University Avenue West, Department of Biology, Wilfrid Laurier University, Waterloo, ON, N2L 3C5; [2]Rua do Campo Alegre 823, Centro Interdisciplinar de Investigação Marinhae Ambiental (CIIMAR), Porto, 4150-180, Portugal. **Reversible Effects of the Pesticide, 3-Trifluoromethyl-4-nitrophenol (TFM), on the Gills of Lampreys and Non-target Lake Sturgeon & Rainbow Trout.**

The pesticide, 3-trifluoromethyl-4-nitrophenol (TFM), is widely used in the Great Lakes to control populations of invasive sea lampreys (Petromyzon marinus). Its capacity to impair mitochondrial ATP production suggests it may interfere with ATP-dependent pathways of the gills in non-target fishes. Accordingly, we measured Na+,K+-ATPase, vacuolar H+-ATPase, and total ATPase activity and plasma Na+ and Cl- concentration in juvenile rainbow trout (Oncorhynchus mykiss) and juvenile lake sturgeon (Acipenser fulvescens) which were exposed to TFM for 0, 3, 6, and 9-h and 12-h followed by a 24-h recovery period. No significant changes were observed in the trout both during TFM exposure and following recovery. Na+ concentration decreased by approximately 20% following 9 h exposure to lampricide, and declined a further 15% following depuration in "clean" water in lake sturgeon. No significant decreases in plasma Cl- were observed, but Cl- concentrations significantly increased by 22 % following recovery in clean water. H-ATPase activity significantly decreased by 50% by 6-h exposures however activity returned to control values by 9-h of TFM exposure. Although TFM is thought to damage the gills in non-target fished, these results suggest that the effects of TFM on gill-mediated ion-exchange are minute and reversible. *Keywords: Pesticides, Fisheries, Risk assessment.*

SOUTHERN, J.A.[1], RAM, J.L.[2], MOYERBRAILEAN, G.A.[2], and KASHIAN, D.R.[1], [1]Wayne State University, Department of Biological Sciences, Detroit, MI; [2]Wayne State University, Department of Physiology, Detroit, MI. **Monitoring Fish Communities in Western Lake Erie: Collection Efficiencies, Invasives, and Community Dynamics over Time.**

Efficient monitoring is essential for early detection of invasive species. Fish survey data from the Ohio Department of Natural Resources (ODNR) was analyzed to determine if trawl and gillnet catches from102 sites in western Lake Erie near the port of Toledo could efficiently detect rare or non-native species. Sixty four species were catalogued spanning 1990-2010. Chao biodiversity analysis used frequency and accumulation data to estimate species richness, compare sampling efficiency, and identify costs for benchmark sampling efficiencies (i.e. 90, 100%). The ODNR sampling accounted for ~80% of extant fish species on average, leaving gaps in coverage where rare and invasive species may proliferate. To achieve 90% efficiency, it's estimated to require approximately a doubling of previous sampling effort. Simulations of different proportions of trawl and gillnet effort indicate the advantage of a mixed effort and a range of effective proportions of the two collection techniques. Several years lag occurred between the initial report of round gobies in Lake St. Clair and their detection in western Lake Erie. These analyses will be used to recommend how to maximize sampling efficiency to provide earlier detection of future introductions, reduce total costs, and facilitate an improved understanding of native community dynamics. *Keywords: Invasive species, Monitoring, Populations.*

SPAK, S.N.[1], PETRICH, N.T.[2], SHANAHAN, C.E.[1], CARMICHAEL, G.R.[2], HU, D.[2], MARTINEZ, A.[2], and HORNBUCKLE, K.C.[2], [1]Public Policy Center, University of Iowa, Iowa City, IA; [2]College of Engineering, University of Iowa, Iowa City, IA. **Spatiotemporal commensurability in passive and active sampling for emerging contaminants of concern and legacy toxics in the Great Lakes region.**

Passive air and water sampling offer cost-effective means of enhancing and expanding long-term monitoring networks for contaminants of concern at weekly to seasonal time scales. To date, the long integration times and sampling rate variability in these techniques have limited opportunities for direct comparison to existing Great Lakes monitoring employing active sampling at daily time scales. Here, we model hourly variability in passive air sampling rates for emerging contaminants of concern and PCB congeners at a Chicago monitoring network, and estimate synthetic hourly concentrations from passive sampling observations. Direct comparison of hourly concentrations from active and passive sampling at co-located sites finds that modeling from passive sampling resolves daily variability in observed concentration. Modeled mass uptake roses support identification of contaminant mass uptake from lake and urban sources over multi-week passive sampling deployments. From these studies, we identify potential artifacts in seasonality and spatial patterns from high volume sampling, and suggest approaches for combining passive and active sampling to enhance monitoring, emerging contaminant source detection, and trends assessments. *Keywords: PCBs, Comparison studies, Toxic substances, Monitoring.*

SPRULES, W.G., BARTH, L.E., and SURUGIU, A., Department of Biology, University of Toronto Mississauga, Mississauga, ON, L5L 1C6. **Effects of Wind on Water Currents at Multiple Depths in the Epilimnion of Lake Opeongo, Ontario.**

Differential responses of planktonic predators and their prey to wind-induced water currents can affect their spatial overlap and hence the flow of energy through the food web. We hypothesize that zooplankton occupying different depth strata in the epilimnion will be transported different distances and directions by wind-induced currents and that the differences will be maximal at intermediate wind speeds. To test this we deployed GPS-equipped drogues at three depths in the epilimnion of Lake Opeongo, Ontario - near surface, the top of the metalimnion and half-way between. Drogues were set in the early morning at two fixed locations 6 km apart up- and downwind of prevailing westerly winds, and at additional up- and downwind locations if the wind direction (monitored by an in-lake weather station) varied from prevailing. Vertical temperature profiles and zooplankton pump samples were collected at the same three depths when the drifters were deployed and again when the drifters were retrieved at noon. This procedure was repeated in the afternoon, and the daily protocol replicated 5 days on each of four visits during spring, summer and early fall. We will present an analysis of the relationship between wind force and water mass movement and, in a companion presentation, the effects on zooplankton. *Keywords: Spatial distribution, Water currents, Atmosphere-lake interaction.*

STADLER-SALT, N.[1], ADAMS, J.[2], CHERWATY-PERGENTILE, S.[1], HINCHEY MALLOY, E.[2], HORVATIN, P.[2], HYDE, R.[1], RODRIGUEZ, K.[2], and TEPAS, K.[3], [1]Environment Canada, Great Lakes Issue Management and Reporting Section, Burlington, ON, L7R 4A6; [2]U.S. Environmental Protection Agency, Great Lakes National Program Office, Chicago, IL, 60604; [3]Illinois-Indiana Sea Grant, University of Illinois, Urbana, IL, 61801. **Overview of Great Lakes Conditions and Trends I: State of Great Lakes Water Quality.**

An overview of current Great Lakes water quality conditions and trends will be presented. The overview is derived from indicator reports prepared by scientists from over two dozen organizations, for the 2011 State of the Lakes Ecosystem Conference (SOLEC), organized by Environment Canada and the United States Environmental Protection Agency. Status and trends to be discussed include nearshore and offshore phosphorus concentrations, levels of toxic chemicals in offshore waters, and contaminant concentrations in fish and waterbirds.
Keywords: Decision making, Ecosystem health, Indicators.

STAHL, J.R.[1], MCMURRAY, P.D.[1], SMITH, J.R.[2], KOMINOWSKI, A.L.[2], and SPARKS, D.[3], [1]Indiana Department of Environmental Management, Office of Water Quality, 100 N. Senate Ave. (MC65-40-2 Shadeland), Indianapolis, IN, 46204-2251; [2]Indiana Department of Environmental Management _OLQ/OLC, 100 N. Senate Ave - N1307, Indianapolis, IN, 46204-2251; [3]U.S. Fish & Wildlife Service - BFO, 620 Sout Walker Street, Bloomington, IN, 47403-2121. **Determination of Beneficial Use Impairment Delisting Potential of the Grand Calumet River Area of Concern: Fish Tissue and Sediment Contaminants Sampling and Analysis.**

More than 150 years of channelization, urbanization, industrial and chemical manufacturing have resulted in extensive degradation of the Grand Calumet River (GCR) basin, a small (175 km2) watershed in northwest Indiana flowing into southern Lake Michigan and the Illinois River Basin. The GCR basin has been designated as an Area of Concern (AOC) requiring a Remedial Action Plan to improve 12 current beneficial use impairments (BUIs). We will present our plan for sampling and analysis of fish tissue and sediment contaminants samples at 20 locations in the GCR AOC in 2013 to determine if recent sediment removal and capping projects have improved the condition of the GCR. We will also present historical data to set the context of contamination in the GCR. Resulting data will support delisting the GCR AOC for BUIs #1 (Restrictions on fish and wildlife consumption), #2 (Tainting of fish and wildlife flavor), #5 (Bird or animal deformities or reproduction problems), #7 (Restriction on dredging activities), removal from the Indiana 303(d) list for the Fish Consumption Use, and updating the Indiana Fish Consumption Advisory. This project is being funded through the Indiana Department of Environmental Management and the Natural Resource Damage Assessment Trust Fund. *Keywords: Fish toxins, BUI's, Sediments, AOC, Environmental contaminants, Impaired water use.*

STATON, J.S.[1], ROSWELL, C.R.[1], TOMAS, T.O.[1], FIELDER, D.G.[2], THOMAS, M.V.[3], and POTHOVEN, S.A.[4], [1]Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN, 47907; [2]Michigan Department of Natural Resources, Alpena Fisheries Research Station, Alpena, MI, 49707; [3]Michigan Department of Natural Resources, Lake St. Clair Fisheries Research Station, Harrison Township, MI, 48045; [4]Lake Michigan Field Station, Great Lakes Environmental Research Laboratory, NOAA, Muskegon, MI, 49441. **Evaluating Differences in Condition of Yellow Perch in Saginaw Bay, Lake Huron (1971-2011).**

Yellow perch (*Perca flavescens*) is an ecologically important component of the Saginaw Bay ecosystem, where it supports both recreational and commercial fisheries. Over the past 40 years the Saginaw Bay ecosystem has experienced a variable suite of stressors including the introduction of exotic species, decreased nutrient loading, and increased temperatures. In turn, abundances and growth rates of yellow perch have fluctuated over time and we expect perch condition to follow similar trends. We calculated annual mean relative weight (W_r) of age-1+ yellow perch for 1970-2011. We found high interannual variation in condition and documented low mean W_r during the 1980s. Information criterion regression models suggest that mean annual W_r was associated with annual yellow perch densities; however, models explained a relatively low amount of variation in annual mean W_r. To consider the role of yellow perch diet composition in structuring condition patterns, we analyzed diets of age-1 and older yellow perch, collected during 2009-2010. During this recent time period, yellow perch consumed a fundamentally different diet (including non-indigenous prey, round goby and *Bythotrephes* spp.) than documented in a previous study during 1986-1988, when Chironoimdae were dominant prey. *Keywords: Yellow perch, Condition, Diets.*

STEFFEN, M.M.[1], BELISLE, B.S.[1], EFFLER, T.C.[1], HAUSER, L.J.[2], BOURBONNIERE, R.A.[3], WATSON, S.B.[3], BOYER, G.L.[4], and WILHELM, S.W.[1], [1]University of Tennessee, Knoxville, TN, 37996; [2]Oak Ridge National Lab, Oak Ridge, TN, 37830; [3]National Water Research Institute, Environment Canada, 867 Lakeshore Road, PO Box 5050, Burlington, ON; [4]4State University of New York, Syracuse, NY, 13210. **Comparison of Microcystis bloom metatranscriptomes and variable nitrogen culture transcriptomes to identify factors that drive bloom events.**

Microcystis aeruginosa is a colonial cyanobacterium capable of forming toxic blooms in ecologically important freshwater lakes. How the suite of abiotic (i.e., temperature) and biotic factors contribute to the bloom-forming ability of *Microcystis* is currently unknown. To better answer the question, "What makes *Microcystis* bloom?" a series of environmental and culture mRNA sequence libraries were generated on the Illumina® platform. All transcriptomes were generated in triplicate for a total of over 200 million reads. Expression patterns of total community mRNA associated with bloom and non-bloom sites from Lake Erie have been compared to provide insight into environmental and community conditions that facilitate *Microcystis* bloom development and success. Triplicate cultures of *M. aeruginosa* NIES 843 grown under varying concentrations and species of nitrogen and phosphorus have been sequenced to compare expression profiles of this important toxin-producing cyanobacterium under different nutrient conditions. These transcriptome data directly answer questions regarding differential gene expression of *Microcystis* under different nitrogen conditions and provide physiological context for bloom forming activity in the environment. *Keywords: Microcystis, Bioinformatics, Lake Erie.*

STEIN, S.R.[1], ROSWELL, C.R.[1], GRIMM, E.F.[2], TROY, C.D.[2], BOWEN, G.[3], WILSON, A.E.[4], and HÖÖK, T.O.[1], [1]Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN, 47907; [2]School of Civil Engineering, Purdue University, West Lafayette, IN; [3]Department of Geology and Geophysics, University of Utah, Salt Lake City, UT; [4]Department of Fisheries and Allied Aquacultures, Auburn University, Auburn, AL. **Habitat characterization of southern Lake Michigan river plumes: Implications for fish recruitment.**

Great Lakes rivermouths and river plumes provide unique transitional habitats between tributary and lake systems. Previous research has demonstrated that in some estuarine and lacustrine ecosystems, river plume habitats enhance young fish growth and survival, thus increasing recruitment to an adult population. In Lake Michigan, fish recruitment is undoubtedly influenced by environmental heterogeneity, but the relative importance of rivermouth habitats for recruitment of many species is poorly understood. To thoroughly characterize the environmental conditions that young fish may experience in Lake Michigan river plumes, during 2011 and 2012, we measured physical variables, collected water, zooplankton, benthic macroinvertebrates, and larval and juvenile fish at five rivermouths in southern Lake Michigan. We analyzed nutrient concentrations of water samples, and identified, enumerated, and measured invertebrates and larval fish. Additionally, we quantified diets and estimated growth rates via otolith microstructures and RNA:DNA of a subsample of fish. Preliminary results indicate that 1) lower

trophic level patterns varied both spatially and temporally within rivermouths, and 2) while larval fish densities did not vary considerably between plume and non-plume sites, RNA:DNA ratios were different across these habtiats in 2012. *Keywords: Fish populations, Tributaries, Habitats.*

STEPIEN, C.A.[1], HAPONSKI, A.E.[1], SEPULVEDA-VILLET, O.J.[2], and SULLIVAN, T.J.[1], [1]University of Toledo Lake Erie Center and Dept. Environmental Sciences, 6200 Bayshore Rd., Toledo, OH, 43616; [2]USDA, 600 E. Greenfield Ave., Milwaukee, WI, 53204. **Comparative Population Genetic Structure of Walleye and Yellow Perch: Interplay of Temporal, Glacial, and Life History Patterns.**

Walleye and yellow perch are two of the most ecologically and economically important freshwater fishes in North America, especially in the Laurentian Great Lakes. Understanding the similarities and differences in their population genetic structures is critical to successful conservation and management. We compare and contrast their hierarchical spatial and temporal genetic patterns from spawning groups across their native North American ranges using nuclear DNA microsatellites and mitochondrial DNA sequences. Results indicate that both species have appreciable and consistent levels of genetic diversity across their native ranges, with walleye being higher than yellow perch due to the latter's apparent propensity for spawning in kin groups. Both walleye and yellow perch show considerable genetic structure across their ranges, and similar patterning of population discontinuities among geographic regions, which trace to their common vicariant and dispersal histories. Genetic composition of spawning groups is stable from year to year in walleye, according to two decades of data, but less consistent in yellow perch. Many of these patterns reflect the interaction of life history and behavioral differences between the two species, contributing to their respective population stock structures.
Keywords: Fish, Walleye, Biodiversity, Yellow perch, Genetics.

STEVENSON, R.J., NOVITSKI, L., HYNDMAN, D., QI, J., ESSELMAN, P., KENDALL, A.D., LAWAWIROJWONG, S., LUSCZ, E.C., MARTIN, S.L., and SUEPA, T., Michigan State University, East Lansing, MI, 48824. **Relating Coastal Algal Blooms to Rivers, Nutrients, Watershed Land Use, and Storm Events.**

The overarching goal of our project was to identify watersheds for restoration that will reduce risk of algal blooms in the coastal zones of the Great Lakes. Existing approaches have been dependent upon use of measured chlorophyll in the relatively few samples collected for the spatial extent and temporal variability in Great Lakes condition. We hypothesized that we could relate algal biomass in the coastal zone of the Great Lakes, nutrient concentrations, watershed land use, and storm events with algal biomass determined using MODIS and Landsat remote sensing images and models of nutrient loads from watersheds based on land use and hydrology. Our models of chlorophyll a based on remote sensing images and nutrient loading in coastal zones were validated with measured chlorophyll concentrations in the Great Lakes and nutrients in rivers. Relationships between watersheds with high nutrient loads and algal blooms were observed, as well as likely relationships with upwelling events. The results of our work indicate

that satellite imagery can be used to infer chlorophyll with sufficient precision to better effects of land use and climate change on algal blooms in coastal zones of the Great Lakes, and to identify priority watersheds for restoration. *Keywords: Algae, Watershed modeling, Remote sensing, Nutrients.*

STEWART, S.R.[1], VAIL, J.H.[2], and KELLY, T.M.[3], [1]Michigan Sea Grant Extension, 21885 Dunham Road, Suite 12, Clinton Township, MI, 48043; [2]Grand Valley State University/AWRI, 740 W. Shoreline Drive, Muskegon, MI, 49441; [3]Inland Seas Education Association, 100 Dame Street, P.O. Box 218, Suttons Bay, MI, 49682. **Vessel Based Education Advancing Great Lakes Literacy.**

Education and outreach are part of the core missions of the GVSU Annis Water Resources Institute (AWRI), Michigan Sea Grant Extension (MSGE), and the Inland Seas Education Association (ISEA). Through onboard education programs conducted on a variety of vessels, these three organizations have served more than 342,000 learners over the past quarter century throughout Michigan and on four of the five Great Lakes. The target audience is mainly K-12 students, but the general public and college students are served as well. A major focus of vessel based education is to provide hands-on science experiences that enhance Great Lakes literacy and lead to stewardship. Although each of the organizations has a unique approach to education and outreach, they all have similar water quality parameters that are measured, recorded and used in a variety of ways. ISEA and AWRI maintain databases of their student-collected data, and MSGE is working to develop a new GIS-based application to allow graphic representations of collected data. *Keywords: Education, Environmental education, Great Lakes basin.*

STOKES, Y.F., WILLIAMS, V.A., and WAGNER, C.A., 106 W. Calendar Court PMB 171, LaGrange, IL, 60525. **A Comparison of Case Studies: What Impacts Whether Summer Gull Management Programs can be Effective at Improving Levels of Escherichia coli in 3 Chicago Beaches.**

Historically, beaches in Chicago, IL have been plagued with excessive Escherichia coli levels. Sources of E. coli, often used as an indicator of the presence of fecal and possibly pathogenic bacteria, have been studied throughout the Great Lakes and have linked the high levels in gull feces with levels in sand and water samples. Wild Goose Chase, in conjunction with the Chicago Park District, implemented a gull management program with the objective of reducing exceedances for 63rd St. and 57th St. Beaches every summer from the end of May through August since 2007 (except 2009), with Montrose Beach added in 2012. The program included daily patrols of varying levels using trained Border collies and handlers to mimic a natural predator, preventing gulls from foraging or loafing. Handlers also educated patrons feeding gulls and picked up trash to reduce food attractants. This can, for the duration of the program, condition gulls to choose another site entirely, leading to significantly reduced levels in E. coli ($p < 0.05$), and therefore exceedances in some beaches. However, the site specific conditions of some beaches, like Montrose Beach, which has a unique ecosystem, may make programs like this ineffective at improving water quality and other sources of E.coli should be determined and managed. *Keywords: Water quality, Gull Management, Ecosystems, Lake management.*

STOLL, J.R.[1] and WINDEN, M.W.[2], [1]2420 Nicolet Drive, MAC B3310, UW-Green Bay, Green Bay, WI, 54311-7001; [2]Hyland Hall 4405, UW-Whitewater, Whitewater, WI, 53190. **Climate Change and Coastal Community Resiliency: An Approach to Disaster Mitigation Policy and Choosing Funding Mechanisms.**

We address a process for identifying economic value of public policy options for disaster relief and community preferences among alternative funding mechanisms. Instability of climatic events is often argued to be related to human production and consumption activities. Reports by the IPCC provide increasing evidence of climatic change and greater public awareness of environmental disasters, whether or not there is agreement on causes. This is especially true of storm related events, creating recognition of the necessity for advance planning of disaster relief efforts in coastal areas. A conceptual model, adapted from the stated-preference literature, reinterprets prior conclusions on valuation technique biases. This model shows how economic value can be estimated for components of community disaster policy. Our approach enables identification of economic value changes associated with alternative methods for funding community disaster relief efforts. Pilot data collection results will be presented to demonstrate the efficacy of the approach. The end result informs policy decision-making processes, enabling policy choices with broader community support. Greater likelihood of implementing disaster relief policies leads to more resilient coastal communities in the face of increasing risks of disaster events. *Keywords: Economic evaluation, Disaster relief, Climate change, Flooding, Policy making, Resiliency.*

STOW, C.A.[1], CHA, Y.K.[2], DYBLE, J.[1], FRANCOEUR, S.N.[3], JOHENGEN, T.H.[2], KASHIAN, D.R.[4], PEACOR, S.D.[5], and WINSLOW, K.[5], [1]NOAA GLERL, Ann Arbor, MI; [2]University of Michigan, Ann Arbor, MI; [3]Eastern Michigan University, Ypsilanti, MI; [4]Wayne State University, Detroit, MI; [5]Michgan State University, East Lansing, MI. **Saginaw Bay Water Quality: Spatial and Temporal Patterns.**

Saginaw Bay has a long history of eutrophication-related symptoms including drinking water taste and odor problems, and decaying organic matter along the beaches. To mitigate eutrophication the 1978 Great Lakes Water Quality Agreement amendments imposed a 440 tonne/year total phosphorus target load, and subsequent recommendations included a spring areawide mean total phosphorus concentration of 15 ug/L, a 3.6 ug/L chlorophyll a concentration and a 3.9 m secchi depth. Our analysis indicates that the phosphorus load has never been met and that the target phosphorus concentration is frequently exceeded, although the "spring areawide mean" may meet this objective, depending on how it is defined. The chlorophyll a and secchi objectives are regularly met in the outer bay, rarely in the inner bay. Recent data indicate that

both soluble reactive phosphorus and ammonia concentrations have declined throughout the bay, while temporal nitrate patterns are unclear. The rationale for imposing a spring total phosphorus concentration limit invites re-evaluation because peak phosphorus and chlorophyll a concentrations generally occur in the late summer with corresponding peaks in cyanobacteria. *Keywords: Water quality, Great Lakes Water Quality Agreement, Eutrophication, Phosphorus.*

STRAKOSH, T.R.[1], ANDERSON, K.R.[2], HENSLER, S.R.[3], and CHAPMAN, D.C.[2], [1]U.S.F.W.S. - Green Bay FWCO, 2661 Scott Tower Drive, New Franken, WI, 54229; [2]U.S.G.S. - Columbia Environmental Research Center, 4200 New Haven Road, Columbia, MO, 65201; [3]USFWS - Alpena FWCO, Waterford Substation, 7806 Gale Road, Waterford, MI, 48327.
Dreissenid Veligers as a Food Source for Silver and Bighead Carp in Lakes Erie and Michigan: a Bioenergetics Model.

The Laurentian Great Lakes have experienced dramatic ecosystem changes within the past 200 years. Two Asian carps (bighead carp Hypophthalmichthys nobilis and silver carp H. molitrix) have colonized the Mississippi and Ohio River basins of central North America and are poised to infiltrate the Great Lakes. Many risk assessment models for Asian carps have focused on zoo- and phytoplankton food sources, but have not included invasive zebra and quagga mussels (Dreissena) veligers in the models. The objective of this study is to assess the potential of Dreissena veligers as a potential food source. Fish Bioenergetics 3.0 was used to model silver and bighead carp growth. The bioenergetics model parameters for both species followed published values with modifications found in other literature. Proportion of maximum consumption was used at the level where fish maintain their weight. Based on the newly developed models Asian carps were able to sustain condition and grow when veliger densities approached and surpassed 1,600 veligers per liter. Previous bioenergetics models that indicate Asian carps may not have an adequate food supply in large portions of lakes Erie and Michigan should be reconsidered with this alternative food source in mind. *Keywords: Bioenergetics, Asian Carp, Biological invasions, Great Lakes basin.*

STREET, G.L., 325 Lake St., Petoskey, MI, 49770. **The Impact of Temperature and Global Warming on the Creation of Sulfuric Acid from Mine Tailings.**

Acid Mine Drainage (AMD) results from the action of water and air on tailings left from the mining of certain sulfide containing ores. It has caused a great deal of environmental damage in the past, and remains an issue today. This paper raises the question of the impact of seasonal temperature variation on the formation of AMD, as well as the impact of Global Warming on the formation of AMD. Preliminary calculations show that both can have a significant impact on the amount of AMD formed. As such, increased ambient temperatures must be taken into account when designing systems to handle AMD. The Arrhenius Equation along with literature values for the Activation Energy were used to make an initial assessment of the impact of temperature. These preliminary calculations show the impact may be very dramatic from seasonal extremes, and enhanced even further by Global Warming. Additional work is needed to more accurately predict the relationship between AMD formation and temperature. Nevertheless, even the

preliminary work presented here strongly suggests that AMD will increase with either or both of these conditions. *Keywords: Acid Mine Drainage, Lake Superior, Global warming, Sulfide Ore, Pollutants.*

STUMPF, R.P.[1], WYNNE, T.T.[1], BAKER, D.B.[2], RICHARDS, R.P.[2], and TOMLINSON, M.C.[1], [1]NOAA National Centers for Coastal Ocean Science, 1305 East-West Highway, Silver Spring, MD, 20910; [2]Heidelberg University, National Center for Water Quality Research, Tiffin, OH. **Inter-annual patterns in cyanobacterial blooms in Lake Erie.**

Lake Erie has experienced a recurrence of cyanobacterial blooms over the last decade, with the summers of 2008 to 2011 having severe blooms. 2012 had a respite with a milder bloom. Using data from the MERIS and MODIS sensors, we have characterized the severity and patterns of the blooms through each summer. The inter-annual variation is described by variations in spring discharge and phosphorus loads from the Maumee River. 2012, while mild in comparison to 2008-2011, was stronger than predicted from the discharge/phosphorus model. 2012 was unusual in that the low load year followed a severe bloom year, but 2012 also had both high phosphorus load during winter and no ice over the lake. Mild blooms have occurred during years with no ice (2002 and 2006), and during the summer following a wet winter (2007), but the combination has not been observed over the 11-year satellite record. *Keywords: Harmful algal blooms, Lake Erie, Phosphorus.*

STURTEVANT, R.A.[1], FUSARO, A.J.[2], RUTHERFORD, E.S.[2], BERENT, L.[3], BOGDANOFF, A.[3], LARSON, J.[3], MCCARTHY, M.[3], NUNEZ, G.[3], and DETTLOFF, K.[3], [1]NOAA - Great Lakes Sea Grant Network, 4840 South State Road, Ann Arbor, MI, 48108; [2]NOAA - GLERL, 4840 South State Road, Ann Arbor, MI, 48108; [3]NOAA - CILER, 4840 South State Road, Ann Arbor, MI, 48108. **Great Lakes Invasive Species Organism Impact Assessments.**

The Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS - http://www.glerl.noaa.gov/res/Programs/ncrais/glansis.html) is a Great Lakes specific node of the USGS Nonindigenous Aquatic Species (NAS) system. As a part of the larger system enhancements funded by the Great Lakes Restoration Initiative, we have undertaken an assessment of the impacts of the more than 180 established nonindigenous species included in the database - including algae, plants, microorganisms, parasites and free-living fauna. All assessments were done using a standardized template assessment tool which was developed by the core team with significant input from our Expert Review Panel. Following a thorough literature review, the Organism Impact Assessment was used to rank the environmental impact, socio-economic impact, and beneficial effect of each species as high, moderate, low, or unknown. By standardizing the assessment process across taxa, the resulting ranks for all 180+ Great Lakes invaders can be directly compared. Importantly, this ranking system provides a method of identifying and comparing impacts across taxa and type of impact. This comprehensive assessment should prove an important tool in guiding future research and setting priorities for AIS control. *Keywords: Invasive species, Assessments, Great Lakes basin.*

STURTEVANT, R.A., NOAA - Great Lakes Sea Grant Network, 4840 South State Road, Ann Arbor, MI, 48108. **Serendipity: Outreach, Education and Policy Careers for the Scientist.**

My personal career track has taken a wandering path somewhat different that the traditional Ph.D. scientist - affording me the opportunity to work in Great Lakes policy, education, outreach and extension as well as at the intersection of each of those fields with research. This talk will share some personal insights for students interested in non-traditional tracks -- as well as perhaps for those who haven't thought along those lines previously. *Keywords: Education, Outreach, Policy making.*

SU, Z., Institute for Fisheries Research, 1109 N. University Ave., Ann Arbor, MI, 48109.
Bayesian spatial-temporal modeling and forecasting of Lake Michigan Recreational fishing effort dynamics.

Bayesian hierarchical dynamic models were built that explicitly take into account temporal dependent (time series) structure in the historical data for each Great Lake fishing site as well as spatial associations among sites. As a case study, we use the models to examine fishing effort dynamics of multiple fishing sites from Lake Michigan. However, such models can be applied to multiple time series data for a wide range of applications. *Keywords: Fisheries, Bayesian, Great Lakes basin, Lake Michigan, Mathematical models, Fishing effort.*

SULLIVAN, D.J.[1], CORSI, S.R.[1], BALDWIN, A.K.[1], RENEAU, P.C.[1], LENAKER, P.A.[1], PELLERIN, B.A.[2], BORCHARDT, M.A.[3], and SPENCER, S.K.[3], [1]U.S. Geological Survey, 8505 Research Way, Middleton, WI, 53562; [2]U.S. Geological Survey, Placer Hall, 6000 J Street, Sacramento, CA, 95819; [3]Marshfield Agricultural Research Station, 2611 Yellowstone Drive, Marshfield, WI, 54449. **Use of Technology to Support USGS Tributary Monitoring for Great Lakes Restoration Efforts.**

The USGS is monitoring 30 tributary sites to support Great Lakes restoration goals. At 8 of these sites, automatic samplers collect water for analysis of pathogens (human-specific and bovine-specific viruses, bacteria, and protozoa) to help determine risk for human contact in these tributaries and nearshore areas. In addition, optical properties of the water (fluorescence and absorbance) are being measured in an effort to develop surrogates for real-time estimates of human and animal-derived waste, mercury and methyl mercury, and other contaminants. Commercially-available sensors that measure humic-rich, terrestrially-derived organic matter are being used in conjunction with laboratory optical measurements to identify optimal wavelengths of interest for the future development of an inexpensive, field deployable sensor to estimate wastewater and other contributions. Preliminary results indicate that addition of sensors at multiple wavelengths will improve estimates of the contaminants of interest. In addition, at 17 of the sites, contaminants including pharmaceuticals, personal care products, and 14 other categories of organic compounds are being analyzed to form the basis of a unique and extensive database of contaminants of emerging concern. *Keywords: Water quality, Organic compounds, Great Lakes Restoration Initiative (GLRI).*

TADDEO, S., SWEETMAN, A.C., OVERMIER, G., KAMINSKI, L., and CRANE, T.R., 2805 South Industial Highway, Suite #100, Ann Arbor, MI, 48104-6791. **Innovative In-stream Control Methodologies for Reducing Nonpoint Source Pollution, Reducing Sediment and Abating Phosphorus Loadings to the Great Lakes.**

The re-emergence of harmful algal blooms (HAB) in the Great Lakes and St. Lawrence River in the last several years is threatening the integrity of the region's water resources and aquatic ecosystems. In response, federal and state governments have become increasingly concerned about nonpoint source pollution, particularly excessive phosphorus, as it appears to be the major contributor to the recent increase in the frequency and severity of HABs throughout the Great Lakes Basin. Addressing the threat of nonpoint source pollution has required the development of targeted water quality improvement programs by scientists and land managers. As a result, numerous best management practices (BMP), both upland and in-stream, have been developed in recent years. However, as states and federal resources are often limited, extensive information is needed to identify new and cost-effective BMPs and successfully implement them at appropriate locations. This poster presents a comprehensive overview of innovative in-stream BMPs used throughout the United States and Canada to reduce nonpoint source pollution and phosphorus loadings, including riparian buffers, reactive materials, and two-stage ditches. Information is provided on the costs and effectiveness of these innovative technologies and successful implementation examples are presented. *Keywords: Phosphorus, Best Management Practice, Harmful algal blooms, Sediments.*

TAN, J.[1], CHERKAUER, K.A.[1], CHAUBEY, I.[1], TROY, C.D.[2], and ESSIG, R.R.[2], [1]Agricultural & Biological Engineering, Purdue University, West Lafayette, IN, 47906; [2]School of Civil Engineering, Purdue University, West Lafayette, IN, 47906. **Monitoring water quality of episodic river inflow plumes in Southern Lake Michigan using remote sensing.**

Large quantities of nutrients and sediments delivered to Lake Michigan following precipitation events contribute significantly to lake water quality impairment. Assessing water quality in episodic river plumes entering Lake Michigan is important for water quality management. This study focuses on two tributaries of Southern Lake Michigan, Trail Creek and the St Joseph River. Two sets of satellite images and coincident spectral and water quality measurements were collected during the summer of 2012. First, a Landsat 7 ETM+ image of the near shore region by Trail Creek was obtained on June 14, 2012 during a period of minimum river flow. Then on August 7, 2012, images were obtained from the EO-1 Hyperion and Advanced Land Imager (ALI) sensors for the near shore region off the St Joseph River. While the Trail Creek image did not capture a visible plume under dry conditions, the images off of the St. Joseph River found a substantial plume after an episodic event. Optically sensitive water quality parameters including chlorophyll-a (chl), dissolved organic carbon (DOC) and total suspended solids (TSS) are quantified through empirical modeling using both in-situ and remote sensing data. Water quality maps are generated to show the water quality condition after the storm event. *Keywords: Lake Michigan, Water quality, Remote sensing.*

TANG, H.[1], VANDERPLOEG, H.A.[2], JOHENGEN, T.H.[3], SARNELLE, O.[4], LIEBIG, J.R.[2], PALLADINO, D.[2], BURTNER, A.B.[3], CAVALETTO, J.[2], MOREHEAD, N.R.[2], and FANSLOW, D.[1], [1]College of Animal Science, South China Agricultural University, Guangzhou, China; [2]GLERL/NOAA, 4840 S. State Road, Ann Arbor, MI, 48108; [3]CILER/University of Michigan, 4840 S. State Road, Ann Arbor, MI, 48108; [4]Department of Fisheries and Wildlife, Michigan State Univeristy, East Lansing, MI, 48824-1222. **There Are No Shortcuts: Phytoplankton Counts Yield Important Information To Understanding Feedbacks Among Grazing, Phytoplankton Composition, and Nutrient Stoichiometry In Natural Systems.**

We are using dreissenid mussels as model consumers to understand the feedbacks among selective feeding, phytoplankton composition, and nutrient stoichiometry. Rarely has selective feeding and nutrient excretion of any consumer been related to phytoplankton composition and stoichiometry in natural systems. Because of their ability to feed upon a broad size range of particles and their abundance in natural systems they can theoretically play a positive role for controlling harmful bloom (HAB) phytoplankton through grazing or a negative role promoting HAB phytoplankton through selective rejection. Likewise, alteration of N:P ratios by nutrient excretion has been hypothesized to promote cyanobacterial HABs. We have used a variety of methods to evaluate these relationships. Detailed phytoplankton counting and nutrient mass balance is necessary to understand feeding and feedbacks with nutrient stoichiometry. We were surprised to find the broad taxonomic categories of phytoplankton even in the same size range were poor predictors of ingestion for cyanobacteria and diatoms. Excretion of P but not of N was strongly negatively associated with Microcystis abundance through the mechanism of lowered feeding rate. Other potential automated techniques on the horizon for counting or species identification are discussed. *Keywords: Algae, Nutrients, Harmful algal blooms.*

TANK, J.L.[1], REISINGER, A.J.[1], ROSI-MARSHALL, E.J.[2], HALL, R.O.[3], and BAKER, M.A.[4], [1]University of Notre Dame, Notre Dame, IN, 46615; [2]Cary Institute of Ecosystem Studies, Millbrook, NY, 12545; [3]University of Wyoming, Laramie, WY, 82071; [4]Utah State University, Logan, UT, 84321. **Nutrient Uptake in 3 Michigan Rivers Reflects a Gradient of Human Land Use.**

River networks regulate nutrient export from terrestrial landscapes, and human land use can increase riverine nutrient loads and impact sensitive downstream ecosystems. We predicted that human-influenced rivers in the Great Lakes Basin would be nutrient-saturated, and exhibit reduced nutrient removal capacity. Using the pulse addition technique, we quantified ammonium, nitrate, and phosphate uptake in 3 rivers draining into Lake Michigan (Manistee, Muskegon, and St. Joseph) that span a land-use and nutrient gradient. Land-use in each watershed ranged from 22-72% developed (agricultural + urban) while discharge ranged from 25.2-37.1 m3/sec. Ammonium uptake velocity was highest in the Manistee River (4.1 mm/min) whose basin is dominated by forested lands (78% of catchment). In contrast, phosphate and nitrate uptake velocities were highest in the St. Joseph River (10.3 and 12.6 mm/min, respectively) despite the 72% developed land use in the basin and elevated nutrient concentrations. Nutrient uptake does not necessarily decline in high-nutrient human-impacted rivers. Understanding controls on nutrient retention in rivers is critical, as removal capacity

appears less likely to saturate as previously predicted, which has significant consequences for downstream ecosystems such as the Great Lakes. *Keywords: Biogeochemistry, Rivers, Nutrients, Water quality, Watersheds, Land Use.*

TAYLOR, D.R. and CHOW-FRASER, P., 1280 Main Street West, Hamilton, ON, L8S 4K1.
Long-term Effects of Impoundment of Georgian Bay Wetlands.

Global climate change has led to sustained low water levels in the upper Laurentian Great Lakes which have caused considerable changes to coastal wetlands. Impounding coastal wetlands is a proposed solution to wetland loss, but the resulting effect on ecosystem functions is largely unknown for the higher quality wetlands that we find in Georgian Bay, Lake Huron. We investigated the potential long-term ecosystem impacts of impoundment on wetlands in Georgian Bay using a series of historical imagery and field sampling. We determined that Wye Marsh, a wetland impounded by a man-made dike for over 82 years shows a general infilling of emergent vegetation through time. Compared to a hydrologically connected wetland of comparable size in the region, Wye Marsh shows no difference in avian species composition. On the other hand, higher trophic level fish species that are more sensitive to degraded conditions were absent from the impounded wetland. We found similar results when comparing the food web of a beaver-impounded wetland ecosystem with an adjacent hydrologically connected wetland. Overall, our results demonstrate that the long-term effects of impoundment of Georgian Bay wetlands are negative for overall biodiversity and are not an adequate solution to sustained low water levels. *Keywords: Georgian Bay, Coastal wetlands, Water level.*

TENCZAR, N.[1], MARINI, L.[1], MCLAREN, T.[1], MINSKER, B.[1], WIETSMA, T.[1], WENZHAO, X.[1], COLLINGSWORTH, P.C.[2], TEPAS, K.[2], and MILLER, B.K.[2], [1]1205 W. Clark St., Urbana, IL, 61801; [2]1101 W. Peabody Dr., Urbana, IL, 61801. **Monitoring the Great Lakes.**

Many federal agencies regularly collect and publish environmental readings from active sensors or individual surveys. These readings could lead to significant insight into ecological and environmental evolution critical to understanding humanity's effect on our surroundings, but only if scientists and researchers can access this data. We propose a web service to aggregate these sources and provide an engine for easy discovery of the data. This service will aggregate data collected in the Great Lakes region by the EPA's regular water quality surveys, NOAA, the USGS, and others, and provide easy access to the data via well-defined RESTful endpoints. We provide a simple web interface for querying this data on four dimensions: time, location, source and parameter. These queries can return the data in multiple formats or provide interactive visualizations using the capabilities of modern web browsers. Finally we provide a means of running analytics on the aggregated data sets. We will discuss the challenges in aggregating these disparate data sets, warehousing the data, and creating intuitive user interfaces for discovering the data. *Keywords: Data storage and retrieval, Great Lakes basin, GIS.*

TEPAS, K.[1], COLLINGSWORTH, P.C.[1], PIJANOWSKI, B.C.[2], HORVATIN, P.[3], HINCHEY MALLOY, E.[3], and MILLER, B.K.[4], [1]Illinois-Indiana Sea Grant, U.S. EPA, Great Lakes Nation Program Office, 77 W. Jackson Blvd. (G-17J), Chicago, IL, 60604; [2]Purdue University, Department of Forestry and Natural Resources,, West Lafayette, IN, 47906; [3]U.S. EPA, Great Lakes Nation Program Office, 77 W. Jackson Blvd., G-17J, Chicago, IL, 60604; [4]Illinois-Indiana Sea Grant, University of Illinois, 1101 W. Peabody Dr., Urbana, IL, 61801. **Development of New Land Use Indicators for SOLEC Assessment.**

The State of the Lake Ecosystem Conference (SOLEC) is co-hosted every 3 years by the U.S. Environmental Protection Agency and Environment Canada. The conference evolved from the Great Lakes Water Quality Agreement reporting requirements for the two parties. Accordingly, at SOLEC, the two governments report out on the health of the Great Lakes' ecosystem based on an assessment of accepted indicators. To enhance this assessment, researchers at Purdue University, along with colleagues at the University of Michigan, Michigan State University, University of Minnesota, University of Windsor, and NOAA-GLERL, have been developing a new suite of land use and agricultural indicators for the Great Lakes basin. As part of the enhancement, Purdue and its partners are also developing associated tipping points (points at which a system enters an undesirable state) for the indicators, to aid in target setting. This presentation will cover the new suite of indicators proposed and the process for their inclusion into the SOLEC assessment. *Keywords: Decision making, Assessments, Indicators.*

THOMPSON, P.[1], BENNION, D.[1], BOASE, J.[2], CHIOTTI, J.[2], CRAIG, J.[1], DROUIN, R.[3], KENNEDY, G.W.[1], MANNY, B.A.[1], READ, J.G.[4], ROSEMAN, E.F.[1], and THOMAS, M.V.[5], [1]USGS Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI, 48105; [2]US Fish and Wildlife Service, Waterford, MI; [3]Ontario Ministry of Natural Resources, London, ON; [4]Michigan Sea Grant, Ann Arbor, MI; [5]Michigan Department of Natural Resources, Mt. Clemens, MI. **Response by Fish to Adaptive Reef Construction Restoring Spawning Habitat in the St. Clair - Detroit River System.**

The St. Clair-Detroit River System extends from southern Lake Huron to western Lake Erie and supports a variety of ecosystem services. However, habitat alteration and exploitation of fish stocks have significantly reduced spawning and recruitment of fish populations. To enhance and restore fish spawning habitat, spawning reefs were constructed at Belle Isle (2004) and Fighting Island (2008) in the Detroit River and in the Middle Channel of the St. Clair River (2012). Natural rock and limestone large enough to inhibit nonnative sea lamprey reproduction were used. Response by several native species including lake whitefish, lake sturgeon, walleye, and suckers was positive and immediate. Pre- and post construction monitoring of egg deposition revealed that the type of substrate is not as important as greater water depth and velocity. Average total egg density increased post construction of the Fighting Island reef from 89 eggs/m2 (2008) to 210 eggs/m2 (2012) and walleye and lake sturgeon egg and larval fish densities increased. Three additional reefs will be constructed by 2014 in efforts to adequately remediate the Beneficial Use Impairment 14 (loss of fish and wildlife habitat) in the St. Clair River and Detroit River Areas of Concern, and provide adequate amounts of suitable spawning substrate for fish. *Keywords: St. Clair River, Spawning Reefs, Detroit River, Habitats.*

THUPAKI, P.[1], PHANIKUMAR, M.S.[1], SCHWAB, D.J.[2], NEVERS, M.B.[3], and WHITMAN, R.L.[3], [1]Department of Civil and Environmental Engineering, Michigan State University, East Lansing, MI, 48823; [2]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI; [3]United States Geological Survey, Great Lakes Science Center, Porter, IN. **Evaluating the role of Sediment-Bacteria Interactions on Escherichia coli Concentrations at Beaches in Southern Lake Michigan.**

Sediment particles in the water column, directly and indirectly, interact with bacteria and influence their fate and transport. In this study, we examine the impact of sediment-bacteria interactions on Escherichia coli (EC) concentrations at beaches in southern Lake Michigan. We simulate hydrodynamics using a nested-grid numerical model based on the Princeton Ocean Model and use a semi-parametric wave model to simulate wave climate and predict bottom shear stress due to wind-generated surface waves. We use a three-dimensional sediment-bacteria interactions model to assess its role on EC concentration in the nearshore region. The results from the numerical models were tested using data collected during a field experiment that extended from July-Aug 2008 and involved multiple ADCP deployments in southern Lake Michigan and daily measurement of EC levels at three beaches in southern Lake Michigan. Results show that plume dynamics of the Burns Ditch outfall dominates EC concentrations at the beaches close to the outfall. However, interactions between sediment and bacteria have a significant impact on EC concentrations at locations farther from the outfall. Despite a low-wave energy environment, sediment resuspension contributes to the overall EC levels at beaches and including resuspension effects increased overall model accuracy. *Keywords: Lake Michigan, Fecal indicator bacteria, Sediment-bacteria interactions.*

TITZE, D.T. and AUSTIN, J.A., Large Lakes Observatory, University of Minnesota - Duluth, 2205 East 5th Street, Duluth, MN, 55812. **Interannual Variability in Lake Superior Thermal Structure (2005-2012) as Observed through an Extensive Mooring Array.**

Several years of moored temperature measurements in Lake Superior have revealed significant spatial and interannual variability of thermal structure, with significant year-to-year variability in winter and summer heat content, thermocline depth, and phenology. Moorings are deployed throughout Lake Superior, each with a thermistor series that spans the water column, to establish a near-continuous year-round temperature record. Of particular mention in this dataset is a stark contrast in thermal structure between the cold winter of 2009 and the warm winter of 2012, during which we observe especially strong and weak negative stratification, respectively. Further, without the use of proxies, the high-resolution record facilitates the characterization and identification of events of phenological significance, such as yearly dates of stratification onset and offset. Viewing our data alongside long-term regional meteorological datasets, we begin to investigate the mechanisms driving these events and the implications of their timing. When heat content is calculated from temperature data and analyzed in concert with lake ice cover data, we find that lakewide ice cover inhibits heat flux between the lake and atmosphere at individual mooring locations to a greater extent than local ice cover. *Keywords: Lake Superior.*

TRAVIS, S.E.[1] and MARBURGER, J.E.[2], [1]University of New England, Biddeford, ME; [2]National Park Service, Porter, IN. **Cryptic Cattail Invasions in National Parks of the Great Lakes Region: The Role of Hybridization.**

Cattails (*Typha*) are reed-like wetland graminoids that have undergone a massive, albeit cryptic, North American expansion over the past hundred years. Although elevated nutrient levels and altered hydrology have long been implicated as drivers of cattail invasiveness, more recent work utilizing DNA markers has confirmed that hybridization is also a contributing factor. Cattails reproduce by both sexual and vegetative means, with the latter being especially prominent among invasive plants. Our work in the Great Lakes Region has shown that hybridization between native *T. latifolia* and exotic *T. angustifolia* creates genotypes with aggressive vegetative growth capabilities, with the result that hybrids typically represent the largest clones in mixed cattail stands. Sexual reproduction by hybrids leads to increasing levels of backcrossing with stand age. Repeated backcrossing with *T. latifolia* could serve to increase the cryptic nature of the cattail invasion by diluting *T. angustifolia* alleles to the extent that they become difficult to detect via conventional genotyping. For example, we have documented genotypically pure, but highly aggressive, *T. latifolia* in the south-central Great Lakes, an area that lies squarely in the path of exotic cattails dispersing from east to west. *Keywords: Invasive species, Marshes, Genetics.*

TROY, C.D.[1], CANNON, D.[1], LIAO, Q.[2], and BOOTSMA, H.A.[2], [1]Purdue University, 550 Stadium Mall Drive, West Lafayette, IN, 47907-2051; [2]University of Wisconsin-Milwaukee, Milwaukee, WI, 53204. **High-resolution, deep-water bottom boundary layer measurements in Lake Michigan.**

The characteristics of bottom boundary layers in the Great Lakes play an important role in determining the benthic exchange of nutrients, pollutants, and biota. This is especially true in the context of invasive dreissenids, whose effective filtration capacity is strongly linked to the hydrodynamics of the bottom boundary layer. However, very few direct measurements exist of flow and turbulence in Great Lakes bottom boundary layers, especially in deeper waters. In this study, a high-resolution experiment was carried out near Milwaukee, WI, in waters of 60m depth. Three velocimeters measured currents over the full water column, including a high-resolution profiler that successfully resolved the bottom 1m of flow to within 15cm of the lake bottom. Time-averaged velocity profiles show good agreement with a logarithmic law very close to the lake bottom, with stronger agreement during episodes of stronger currents. Near-inertial internal waves are shown to provide some variability to the near-bottom currents, but sub-inertial (>18hr) processes dominate the near-bottom flows. Direct turbulent stress measurements are compared to stress estimates from the logarithmic profile fits. *Keywords: Mussels, Coastal engineering, Hydrodynamics.*

TSEHAYE, I. and JONES, M., Quantitative Fisheries Center, Department of Fisheries and Wildlife, East Lansing, MI, 48824. **Changes in the salmonine community of Lake Michigan and their implications for predator-prey balance.**

We combined statistical stock assessment methods with bioenergetics calculations to assess historical changes in the Lake Michigan salmonine community and their consumptive demands, with the goal to examine their implications for the lake's predator-prey balance. Our results suggested that changes in salmonine abundance and their consumptive demands may have caused long-term fluctuations in the predator-prey balance. These suggestions were consistent with historical changes in prey abundance. Most significantly, the increased salmonine abundance and associated changes in population dynamics in the early 1980s corresponded with the marked decline in alewife abundance prior to the Chinook salmon mass mortality event in 1987. For the most recent years, our results showed improved survival rates and natural reproduction of Chinook salmon leading to a higher abundance of the adult population. These increased adult densities corresponded with historically low levels alewife abundances during the same period, suggesting that increased predation pressure may have caused reduced recruitment of alewife. Although revisions to stocking rates implemented in the past may have stabilized the system, our analysis suggests that recent reductions in stocking have not been sufficient to reduce predatory pressure on the alewife population. *Keywords: Lake Michigan, Salmon, Predation.*

TUCKER, A.J.[1], CHADDERTON, W.L.[1], JERDE, C.L.[2], MAHON, A.M.[3], WITTMANN, M.E.[2], SIERACKI, J.L.[4], BOSSENBROEK, J.M.[4], BELETSKY, D.[5], and LODGE, D.M.[2], [1]The Nature Conservancy, South Bend, IN, 46617; [2]University of Notre Dame, Notre Dame, IN, 46556; [3]Central Michigan University, Mt. Pleasant, MI, 48859; [4]University of Toledo, Oregon, OH, 43618; [5]University of Michigan, Ann Arbor, MI, 48108. **eDNA surveillance for Eurasian Ruffe in the Laurentian Great Lakes.**

First detected in St Louis River, Duluth in 1986, a non-native fish, Eurasian ruffe (Gymnocephalus cernuus) has steadily spread along the southern shoreline of Lake Superior. More recently, ruffe has invaded Green and Thunder Bays in Lakes Michigan and Huron, probably as a result of ballast water mediated dispersal events. Recent assessments of natural dispersal suggest ruffe larvae have likely spread out of Green Bay and should be starting to invade the western shoreline of Lake Michigan. Analyses of Great Lakes shipping patterns indicate that Lake Erie and ports in Southern Lake Michigan may be vulnerable to introductions from ballast water taken up from invaded ports within Lake Superior or Green Bay. Here we report on the initial results of environmental DNA surveillance efforts aimed at identifying the extent of Eurasian ruffe populations in lakes Michigan, Huron and Erie. Sampling focused on the putative leading edge of the invasion in western regions of lakes Michigan and Huron, as well as ports considered to be most at risk from potential ballast water introductions in southern Lake Michigan and western Lake Erie. We discuss the management implications of potential ruffe establishment in Lake Erie and the Southern Basin of Lake Michigan. *Keywords: Exotic species, Invasive species, Monitoring.*

TURNER, C.R., BARNES, M.A., XU, C.C.Y., JERDE, C.L., and LODGE, D.M., Department of Biological Sciences and Environmental Change Initiative, University of Notre Dame, Notre Dame, IN, 46556. **Particle size distribution and optimal capture of fish environmental DNA.**

Aqueous macrobial environmental DNA (eDNA), the DNA-containing material shed by large organisms into water, has recently gained attention as a source of genetic information about the location, abundance, and diversity of aquatic and terrestrial macrobes. Understanding the relationship between eDNA and the organism it came from is critical for assessing how well eDNA can serve as a proxy for directly observing the organism. To better describe this relationship we measured the naturally occurring particle size distribution (PSD) of aqueous eDNA for a model fish (common carp, *Cyprinus carpio*) and compared this with PSDs of total eDNA and total suspended solids in the same water bodies. Carp eDNA represented a tiny fraction of total eDNA and most carp eDNA was found at particles sizes larger than 1.0 µm. The PSD suggests that extracellular DNA is only a minor constituent of fish eDNA suspended in water. These results also provide guidance for optimizing the capture of fish eDNA when searching for rare species that are difficult to detect another way. As eDNA-based monitoring of aquatic ecosystems integrates across the microbial/macrobial divide, these findings will help improve data collection and interpretation. *Keywords: Fish, Rare species, Genetics, Environmental DNA, Biomonitoring, Invasive species.*

TURSCHAK, B.A.[1], BOOTSMA, H.A.[1], JANSSEN, J.[1], CZESNY, S.J.[2], and HÖÖK, T.O.[3], [1]University of Wisconsin-Milwaukee, School of Freshwater Sciences, 600 E. Greenfield Ave., Milwaukee, WI, 53204; [2]University of Illinois, Illinois Natural History Survey, 400 17th Street, Zion, IL, 60099; [3]Purdue University, Department of Forestry and Natural Resources, 195 Marsteller Street, West Lafayette, IN, 47907. **Changes to the Lake Michigan Trophic Structure as Revealed by Stable C and N Isotopes.**

Major biomass declines of pelagic and profundal fish and invertebrates in Lake Michigan have been attributed to the proliferation dreissenid mussels. Conversely, nearshore algal and invertebrate productivity has apparently benefitted from high dreissenid densities. In order to assess changes in energetic pathways and trophic structure during the period of dreissenid mussel proliferation and major ecosystem changes, we used stable carbon and nitrogen isotopes to elucidate primary basal energetic source(s) and trophic level of organisms within the Lake Michigan food web. Sampling took place during three distinct periods 2002-2003, 2005-2006 and 2010-2011, and included nearshore, pelagic and profundal fish and invertebrate taxa. Magnitude and direction of the carbon isotope shift during this period indicated significantly greater reliance upon nearshore benthic energy sources among nearly all fish taxa as well as profundal invertebrates. We propose that the carbon isotope shift has likely resulted from the offshore transport of nearshore benthic algal production, direct reliance upon nearshore prey items, or some combination of both. N isotopic changes over time were more variable but further illustrate restructuring of the Lake Michigan food web. *Keywords: Stable isotopes, Nearshore Zone, Food chains, Invasive species.*

TYLER, J.[1], RUTHERFORD, E.S.[2], WILEY, M.J.[3], RISENG, C.M.[3], PIJANOWSKI, B.C.[4], and HYNDMAN, D.[5], [1]Fisheries Projections, Farmington, CT; [2]NOAA Great Lakes Environmental Laboratory, Ann Arbor, MI; [3]University of Michigan, School of Natural Resources and the Environment, Ann Arbor, MI; [4]Purdue University, Department of Forestry and Natural Resources, West Lafayette, IN; [5]Michigan State University, Department of Geological Sciences, East Lansing, MI. **Changes in Land Use and Urban Development on Salmonid Production in the Muskegon River: A Multi-Modelling Analysis Focused on Chinook and Steelhead.**

We examine how changes in land use affect Chinook salmon populations in the Muskegon River watershed using the Muskegon River Environment Modelling System (MREMS). MREMS combines models of regional climate, high-resolution GIS models of the watershed landscape and land transformation, hydrologic process models, high resolution models of instream hydrodynamics and spatially explicit maps of macroinvertebrates. The environmental outputs of MREMS provide the model river for a new, multi-year version of the Fisheries Projections River Analysis System Individual-Based Model (FPRAS-IBM) built for Chinook Salmon populations. With the FPRAS-IBM we simulate how Chinook populations respond to differences in the proportion of the landscape used for urban, agricultural or forestry purposes. We compare these results to those performed in an earlier study of steelhead production. Simulation results show that differences in land use have a notable effect on Chinook populations, but that water levels in the river interact with this effect. In addition, the differences in the life history of Chinook and steelhead cause the populations to not always respond similarly to land use changes. *Keywords: Model studies, Muskegon River, Salmon, Land Use, Urbanization.*

U'REN, S.J., The Watershed Center Grand Traverse Bay, 13272 S. West Bay Shore Drive, Traverse City, MI, 49684. **Grand Traverse Bay Watershed - Great Lakes Restoration Initiative Beach Restoration Projects.**

The Watershed Center's (TWC) mission is advocating for clean water in Grand Traverse Bay and protecting and preserving the Bay's watershed. During the past six years we have implemented our Healthy Beaches Program which includes bacteria monitoring; source tracking work at local beaches; education via advertising and social media; and large-scale Best Management Practices at beaches to reduce bacterial contamination. In June 2012 TWC completed the first GLRI funded beach remediation project in Michigan at Bryant Park in Traverse City in partnership with the Michigan Department of Environmental Quality. The project involved installing a large-scale underground infiltration system to reduce bacterial contamination at the beach. In 2011 TWC was awarded two GLRI grants to protect public health and reduce bacterial contamination from stormwater runoff at East Bay Park Beach in Traverse City and two beaches in the Village of Suttons Bay. Both projects are on track for successful completion in 2013. The Suttons Bay project will showcase how green infrastructure and low impact development can be used to infiltrate a large percentage runoff before reaching the Bay. The Bryant and East Bay Park projects in Traverse City showcase more urban methods using end-of-the-pipe stormwater treatments located underground. *Keywords: Great Lakes Restoration Initiative (GLRI), Beaches, Stormwater.*

UNITIS, M.J., MURRY, B.A., and UZARSKI, D.G., Institute for Great Lakes Research, Biology Department, Central Michigan University, Engineering and Technology Office 200, Mount Pleasant, MI, 48859. **Differential Use of Three Wetland Types as Nursery Habitat for Juvenile Gamefish Species.**

Great Lake coastal wetlands are commonly known to be an integral part of many fish species life histories, however, the importance of different wetland types to juvenile fish production has not received adequate attention. Of particular interest is the relative abundance and diversity of juvenile gamefish across major wetland types. We conservatively classified fish as juvenile when their length was less than 70% of the lowest published length at first reproduction for each species. The objective of this study was to evaluate differences in juvenile game fish abundance, diversity, and evenness in fringing, protected, and riverine Great Lake coastal wetlands. Sixty-six sites were sampled using Great Lakes Coastal Wetland Consortium accepted trap netting protocols. Sites were sampled during the summer (June to mid-August) of 2011 and 2012. We used analysis of variance and regression approaches to assess differences in juvenile fish diversity, relative abundance and evenness among wetland types. Preliminary analyses suggest that protected wetlands have the highest diversity and abundance of juvenile game fish. Overall, our study suggests differential importance of wetland type as nursery habitats for game fish. This information may prove useful when prioritizing wetlands for conservation.
Keywords: Fish populations, Wetlands, Habitats.

URBAN, N.R., PERLINGER, J.A., MACLENNAN, C.A., SCHWAIGER, E.M., and MANDELIA, A.J., Michigan Technological University, 1400 Townsend Dr., Houghton, MI, 49931. **An Integrated Assessment of the Torch Lake Area of Concern: Phase 1.**

Historical contamination is inextricably linked with cultural legacy; that legacy can impede or advance remediation efforts. A perception exists that the Torch Lake Area of Concern (AOC) is not in the vanguard of AOC sites capitalizing on recent availability of funding and making headway towards remediation and delisting. An Integrated Assessment was funded by Michigan Sea Grant 1) to gather and to summarize existing information regarding conditions in the AOC; 2) to communicate with stakeholders information about the status of the site as well as stakeholders' ideas for and visions of future conditions in the AOC; and 3) to identify and to begin to evaluate potential remedial actions that could mitigate any remaining undesirable conditions. Our preliminary findings belie the impression above. This talk will review the history of site contamination and its cultural setting; new findings based on archival research and interviews with long-time residents point to potential next steps in remediation. The talk will then illustrate the timeline of remedial efforts, and the synergies that have and/or could be developed among stakeholders and the diverse agencies with separate mandates and priorities for clean-up. Coordination and clarity have not been prerequisites for progress to date.
Keywords: Assessments, Environmental contaminants, Public participation.

UZARSKI, D.G.[1], COOPER, M.J.[2], BRADY, V.J.[3], SHERMAN, J.S.[1], and WILCOX, D.A.[4], [1]Institute for Great Lakes Research, CMU Biological Station, Department of Biology,, Central Michigan University, Mount Pleasant, MI, 48859; [2]Department of Biological Sciences, University of Notre Dame, Notre Dame, IN, 46556-0369; [3]Natural Resources Research Institute, University of Minnesota, Duluth, MN, 55811; [4]College at Brockport, Brockport, NY, 14420.
Use of a Basin Wide Great Lakes Coastal Wetland Monitoring Program to inform and Evaluate Protection and Restoration Efforts.

Formed in 2000, the Great Lakes Coastal Wetlands Consortium began developing a basin-wide monitoring plan to determine status and trends of ecosystem health using indices of biotic integrity. The plan was finalized in 2008 and implementation for preservation and restoration purposes began in 2010. Chemical and physical parameters, vegetation, invertebrate, fish, amphibian, and bird data were collected from randomly selected Great Lakes coastal wetlands across the basin using standardized protocols. This stratified random design was intended to inform future protection and restoration efforts. However, additional wetlands designated to receive protection or restoration funds were also sampled to evaluate the success of these efforts. Great Lakes Restoration Initiative (GLRI) programs and projects have much to gain from research as well as monitoring components and our project has been able to assume these responsibilities where applicable. *Keywords: Coastal wetlands, Monitoring, Indicators.*

VACCARO, L.E.[1], MANNY, B.A.[2], READ, J.G.[1], BENNION, D.[2], KENNEDY, G.W.[2], ROSEMAN, E.F.[2], BOASE, J.[3], THOMAS, M.V.[4], CHILDS, M.[5], DROUIN, R.[6], and DIANA, J.S.[1], [1]Michigan Sea Grant, 520 E. Liberty St., Suite 310, Ann Arbor, MI, 48104; [2]USGS Great Lakes Science Center, Ann Arbor, MI, United States; [3]US Fish and Wildlife Service, Alpena, MI; [4]Michigan Department of Natural Resources, Harrison, MI; [5]Essex Regional Conservation Authority, Essex, ON; [6]Ontario Ministry of Natural Resources, London, ON. **Careful science with a compelling mission: Restoring fish communities in the St. Clair - Detroit River System.**

In the late 1800s and early 1900s, the St. Clair - Detroit River System supported large populations of lake sturgeon, whitefish and walleye and a highly profitable commercial fishery. Analysis of historical records reveals how the construction of shipping channels removed or covered highly productive spawning areas, which contributed to fish population declines. Ecological studies indicate that access to suitable fish spawning habitat continues to hinder the recovery of native fish. To mitigate historical habitat losses, a broad coalition of organizations has constructed three rock-rubble, fish spawning reefs in the St. Clair and Detroit Rivers. Differences between reef projects have been examined, including fish preferences for different rock substrates, reef locations and hydrologic conditions. Pre and post restoration monitoring and hydrodynamic modeling have improved our ability to effectively site, design, construct and evaluate artificial reefs. Fourteen species of native fish, including lake sturgeon, lake whitefish and walleye, have spawned on the artificial reefs. Positive results and effective communication tools have helped project partners secure funding and apply the best available science to develop new, cost effective restoration projects. *Keywords: Decision making, Remediation, Fish populations.*

VAIL, J.H.[1], STEWART, S.R.[2], and KELLY, T.M.[3], [1]GVSU Annis Water Resources Institute, 740 W. Shoreline Drive, Muskegon, MI, 49441; [2]Michigan Sea Grant Extension, 21885 Dunham Road, Suite 12, Clinton Township, MI, 48043; [3]Inland Seas Education Association, P.O. Box 218, Suttons Bay, MI, 49682. **Coordinated On-board Education and Outreach Project (COEOP).**

The Coordinated On-board Education and Outreach Project (COEOP), funded by the Great Lakes Restoration Initiative, provides students and the general public a unique opportunity to experience the Great Lakes through the lens of scientists, policy-makers, and local stewardship groups. COEOP is a collaboration of Grand Valley State University Annis Water Resources Institute (AWRI), Michigan Sea Grant Extension (MSG), and Inland Seas Education Association (ISEA) to provide custom-designed onboard education and outreach opportunities for a variety of audiences. Cruises, open houses, and educator workshops are conducted on three of the Great Lakes (Michigan, Erie, and Huron) plus Lake St. Clair, Detroit River, and St. Marys River. These programs highlight the Great Lakes Restoration Initiative, lake-specific management plans, stewardship projects, and Areas of Concern (AOCs). Participants gain an awareness of ecosystem health, water quality, stewardship projects, lake-wide and connecting corridor issues, and the plans to address these issues. The project builds on the success of our Coordinated Lake-specific Onboard Education and Outreach Project (CLOEOP) that was funded through a 2010 GLRI grant. That project serviced thousands of participants at a variety of ports in the upper Great Lakes in 2011 and 2012. *Keywords: Public education, Great Lakes Restoration Initiative (GLRI), Education.*

VAN METRE, P.C., MAJEWSKI, M.S., MAHLER, B.J., FOREMAN, W.T., BRAUN, C.L., WILSON, J.T., and BURBANK, T.L., 1505 Ferguson Road, Austin, TX, 78754. **Large Volatilization Losses of PAHs Soon After Application of Coal-Tar-Based Pavement Sealant.**

Coal-tar-based pavement sealants, a major source of PAHs to urban water bodies, have recently been identified as a source of volatile PAHs to the atmosphere. We tracked the volatilization of PAHs for 1 year after application of a coal-tar-based pavement sealant by measuring gas-phase PAH concentrations above the pavement surface and solid-phase PAH concentrations in sealant scraped from the surface. Gas-phase concentrations at two heights (0.03 and 1.28 m) and wind speed were used to estimate volatilization flux. The sum of the concentrations of eight frequently detected PAHs (sumPAH8) in the 0.03-m sample 1.6 h after application (297,000 ng/m3) was about 5,000 times greater than that previously reported for the same height above unsealed parking lots (66 ng/m3). Flux at 1.6 h after application was estimated at 45 mg/m2/h and decreased rapidly during the 45 days after application. Loss of PAHs from the adhered sealant also was rapid, with about a 50% decrease in solid-phase sumPAH8 concentration over the 45 days after application. Combining the estimated mass of sumPAH8 released to the atmosphere with a national-use estimate of coal-tar-based sealant suggests that PAH emissions from new coal-tar-based sealcoat applications each year are larger than annual vehicle emissions of PAHs for the United States. *Keywords: PAHs, Atmosphere-lake interaction, Pollution sources.*

VANDERPLOEG, H.A.[1], LIEBIG, J.R.[1], CAVALETTO, J.[1], RUTHERFORD, E.S.[1], MASON, D.M.[1], RUBERG, S.A.[1], CONSTANT, S.A.[1], POTHOVEN, S.A.[1], FAHNENSTIEL, G.L.[2], NALEPA, T.F.[3], BUNNELL, D.B.[4], WARNER, D.M.[4], MADENJIAN, C.P.[4], PEACOR, S.D.[5], and RADKA PICHLOVÁ-PTÁCNÍKOVÁ, R.[6], [1]GLERL/NOAA, 4840 S. State Road, Ann Arbor, MI, 48108; [2]Michigan Technological University, Great Lakes Research Center, Houghton, MI, 49931; [3]Graham Sustainability Institute, University of Michigan, Ann Arbor, MI, 48104; [4]USGS Great Lakes Science Center, Ann Arbor, MI, 48105-2807; [5]Michigan State University, Fisheries and Wildlife Department, East Lansing, MI, 48824-1222; [6]WasserCluster Lunz-Biological Station GmbH, A-3293 Lunz am See, Lunz am See, Austria. **Life on the edge: Remarkable changes in spatial connections of the pelagic food webs of Lakes Michigan and Huron over the diel cycle and across years.**

Expansion of dreissenid mussels into all depth zones of Lakes Michigan and Huron has not only reengineered nutrient cycling, water clarity, and spatial distribution and abundance of phytoplankton but also spatial coupling among components of the food web in both horizontal and vertical space. We observed fine-scale vertical spatial structure plankton and fish along long cross-isobath transects using the plankton survey system (PSS) and fishery acoustics during day and night in April, July, and September in Lakes Michigan (2010-11) and Huron (2012). We examined diel changes in fish and plankton distributions at fixed shallow, mid-depth, and deep sites using PSS/acoustics as well as opening/closing nets to sample zooplankton. Across-isobath concentrations of nutrients, light, and plankton were consistent with nutrient loading and dreissenid mussel densities as hypothesized by the mid-depth sink and nearshore shunt paradigms. There was remarkable diel vertical migration of zooplankton between the upper hypolimnion and epilimnion, and temperature rather than light or chlorophyll concentration defined vertical distribution during the day. Despite large changes in phytoplankton concentration and distribution and increase in light over 10 years, only subtle changes in vertical distribution of zooplankton were found in late summer. *Keywords: Food chains, Lake Huron, Lake Michigan.*

VANNIER, R.G., WEI, Y., LONG, D.T., and ROBINSON, A.M., Department of Geological Sciences, Michigan State University, East Lansing, MI, 48824. **Spatial and Temporal Trends of Polychlorinated Biphenyl Inventories and Accumulation Rates in Michigan Inland Lake Sediments.**

Polychlorinated biphenyls (PCBs) are synthetic organic chemicals which were widely used as a dielectric and coolant fluid from 1929-1979 after which they were banned due to environmental toxicity. However, numerous studies have shown that PCBs tend to accumulate and persist primarily in the organic fraction of soil and sediments physical and chemical stability. This provokes questions as to the present state of environmental recovery. Previous studies have shown that PCB emission and redeposition continue to serve as a mode of redistribution since the chemicals initial introduction to the environment. It is hypothesized that, since the ban on PCBs, environmental cycling has changed the distribution of PCBs from localized patterns in proximity to urban areas, to a more regional signal. This hypothesis was tested by examination of sediment cores collected from 34 widely distributed lakes in the State of Michigan. Results show

that elevated concentrations were localized to urban sources in sediment dated to the 1970s and this distribution has since become more diffuse, validating the hypothesis. However, these patterns appear to be influenced by sediment organic carbon content and volatility amongst the individual PCB congeners. *Keywords: Sediments, PCBs, Pollution sources.*

VERHAMME, E.M., DEPINTO, J.V., and REDDER, T.M., LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108. **Ecosystem Dynamics in Saginaw Bay: Insights into Nutrient Transport and Eutrophication Using Models.**

As part of a NOAA-funded project to assess the relative impacts of multiple stressors on multiple ecosystem responses in Saginaw Bay, we have developed a process-based, fine-scale linked hydrodynamic-advance eutrophication model to examine the stress-response relationships of concern. The model, called SAGEM2, includes nutrient dynamics, lower food web interactions, Dreissenid growth and impacts on nutrient cycling and light regime, and Cladophora growth, sloughing, and fate of sloughed material. We have used this model, which has been calibrated to 2009 project data, to examine the growth response of Microcystis and Cladophora to alterations in phosphorus loading and to adjustment of Dreissenid density. A component analysis of the model results will be conducted to illustrate the processes that are most responsible in governing the responses. *Keywords: Model studies, Eutrophication, Ecosystem modeling.*

VERHAMME, E.M. and PETERSON, G.W., LimnoTech, 501 Avis Drive, Ann Arbor, MI, 48108. **From Fishing to Forecasting: The Present and Future of Real-Time Marine Observations in the Great Lakes.**

Within the last decade the number of real-time marine observation stations on the Great Lakes has more than tripled from 100 stations in 2000 to over 300 today. This network is dominated by stations located on fixed structures on the shoreline. However, within the last five years, the number of buoy based stations has doubled from 20 in 2007 to over 40 in 2012. These new buoy stations are located much closer to shore than the traditional NOAA and Environment Canada buoy network and are serving the needs of new user groups including scientists, weather forecasters, and fishermen. Innovations in technology and the expansion of the cellular phone network have driven down the cost to deploy and maintain these buoys. Long term funding to maintain existing stations and establish new ones is a concern. This presentation will review the current state of marine observations and what this network might look like ten to twenty years from now. *Keywords: Observing systems, Buoys.*

VERHOUGSTRAETE, M., MARTIN, S.L., KENDALL, A.D., HYNDMAN, D., and ROSE, J.B., 480 Wilson Road, Fisheries and Wildlife, East Lansing, MI, 48824. **Microbial Responses to Land, Physical, Chemical, Environmental, and Hydrological Factors.**

A snapshot survey of 64 rivers discharging to the Great Lakes quantified E. coli and Bacteroides thetaiotaomicron under baseflow conditions. Bacteroides thetaiotaomicron was detected in all samples (X = 5.1 log10 Cell Equivalents 100 ml-1). The E. coli geometric mean across all rivers (1.4 log10 MPN 100 ml-1) suggests a potential regional reference condition. Classification And Regression Tree analysis indicated the total number of septic system in a watershed significantly impacted Bacteroides thetaiotaomicron concentrations under baseflow conditions. Land use characteristics better predicted microbial water quality than land use type.

VISWANATHAN, C., KAOUKIS, N., MORELAND, J.R., and DORWORTH, L., Purdue University Calumet, 2200 169th St., Hammond, IN, 46323. **Influence of Land Use, Precipitation and Mean Monthly Temperature on High Flow Trends in an Urban Watershed.**

The following study looks at various factors influencing high flows in Hart Ditch, Little Calumet East Arm, and Deep River, subwatersheds of Lake Michigan located in Northwest Indiana. High flow trends were initially examined using qualitative and quantitative analyses. Using 15 years of land use data, monthly rainfall, and mean monthly temperature data, artificial neural network models were trained to predict the number of high flow days having flow more than a 15 % probability of exceedance. An index, called relative strength effect, was calculated for each input after training the ANN model. Based on this index, the effect of different land use categories, temperature, and precipitation over high flow events were computed and documented. For the high flow regime, this study indicates a greater influence of the climate variables than the land use factors. Using the Hydrologic Modeling System, simulations have been created to help understand the effect that land use changes may have on these watersheds. Software has been developed using the simulations to aid the viewer with interaction and visualization of both historic and possible future land use. *Keywords: Climate change.*

VOTAVA, J.E.[1], JOHNSON, T.C.[1], NOREN, A.[2], and HECKY, R.E.[1], [1]Large Lakes Observatory, 2205 E. 5th St., Duluth, MN, 55812; [2]LacCORE, 500 Pilsbury Ave. SE, Minneapolis, MN, 55455. **Lake Kivu Carbonate Deposition: Abrupt, Recent Onset or Rhythmic Fluctuations?**

Lake Kivu, a deep meromictic East African Rift lake, has complex stratification imposed by hydrothermal springs and deep waters supersaturated at STP in CO_2 and CH_4 gasses. An abrupt rise in carbonate (TIC) deposition over the last 50 years has been previously reported and attributed to eutrophication which is cause for concern as this may lead to increased methane production, pushing CH_4 concentrations towards the in situ saturation limit and increasing the risk of spontaneous gas release. Previous evidence for recent increase in TIC came from cores 150 - 190 m below the seasonal depth limit of oxygen penetration. Our study of four new gravity

cores from depths above permanent anoxia(70m) in two separate, sheltered embayments indicate no recent rise in carbonate but do show an earlier period of elevated TIC. Two new deep water gravity cores (>350m) do show a recent rise in TIC, but those cores also reveal past episodes of high TIC periods. We hypothesize the most recent rise in $CaCO_3$ content is actually a recovery to previous carbonate burial rates. Rather than this recent onset being caused by changes in external nutrient loading, it is part of a quasi-rhythmic long term internal behavior resulting in deep waters more or less favorable to carbonate preservation. *Keywords: Africa, Lithostratigraphy, Carbon cycle, Calcium carbonate, Paleolimnology.*

WAGNER, T.S.[1], VAN MAREN, B.[2], SITTONI, L.[2], SHEETS, B.A.[1], VAN ROOIJEN, A.[2], and BANKSTON, J.L.[1], [1]Barr Engineering Company, 4700 W 77th Street, Minneapolis, MN, 55435; [2]Deltares, 185 Rotterdamsweg, Delft, 2629 HD, Netherlands. **Translating an Observation-based Conceptual Site Model to a Hydrodynamic and Morphodynamic Numerical Model of a Great Lakes Estuary.**

Freshwater estuaries, particularly those along the shores of the Great Lakes, present a unique and complicated set of processes that can be difficult to characterize. Processes range from sediment and water discharge, to wave climate, to water level changes associated with large lake dynamics such as seiche. In addition to these, local bathymetry and bed sediment characteristics can play a critical role in controlling system evolution. In order to comprehensively understand and interrelate these phenomena, site data (baseline field observations, historical information, etc) should be synthesized into a Conceptual Site Model (CSM). The CSM, in turn, acts to emphasize important, site-specific, processes, which can then be targeted for more careful field investigation. Finally, the CSM serves as an organized, quantitative basis for development of parameters and boundary conditions needed for hydrodynamic and morphodynamic numerical modeling. Numerical models developed through this methodology are more likely to faithfully represent all important processes, and more easily validated, due to the availability of comprehensive data from the project site.
Keywords: Sediment transport, Model studies, Coastal processes.

WANG, B.[1], FILLINGHAM, J.H.[2], LIAO, Q.[1], and BOOTSMA, H.A.[2], [1]Department of Civil Engineering and Mechanics, University of Wisconsin - Milwaukee, Milwaukee, WI, 53211; [2]School of Freshwater Sciences, University of Wisconsin - Milwaukee, Milwaukee, WI, 53204. **Evaluating gas transfer velocity with in situ free floating PIV/floating chamber measurements.**

Gas transfer velocity across the air-water interface is practically parameterized by a variety of environmental factors such as wind speed, current speed, surface layer buoyancy, wave breaking, precipitation, and the water depth. The gas transfer mechanism is controlled by turbulent eddies which force the periodic renewals of the surface diffusive boundary layer. The small scale eddy model has been shown to correlate well with measured transfer velocities, however, the coefficient in the small scale eddy model depends on the location where the near surface dissipation rate is measured. In this study, we carried out a series of simultaneous

measurements of CO_2 flux and near surface turbulence structures with a free floating PIV and floating chamber system in the coastal area of Lake Michigan. The results show strong correlation between transfer velocity and near surface turbulence on very short temporal scales. The Reynolds number dependence on the coefficient factor in small scale eddy model was found. We provide an empirical method to modify the small scale eddy model, which improves the determination factor of the linear regression from $R^2 = 0.65$ to 0.97. We also found that the impact of chamber on near surface turbulence enhanced the transfer velocity by approximately 1.6 in this study. *Keywords: Gas transfer velocity, Hydrodynamics, Near surface turbulence, Air-water interfaces, Lake Michigan, CO2 flux.*

WANG, J.[1], BAI, X.[2], AUSTIN, J.A.[3], ASSEL, R.[2], BRATTON, J.F.[1], COLTON, M.[1], LENTERS, J.D.[4], LOFGREN, B.M.[1], SCHWAB, D.J.[1], and CLITES, A.[1], [1]NOAA GLERL, 4840 S State Road, Ann Arbor, MI, 48108; [2]University of Michigan CILER, 4840 S State Road, Ann Arbor, MI, 48108; [3]University of Minnesota Duluth, Duluth, MN; [4]University of Nebraska-Lincoln, 3310 Holdrege Street, Lincoln, NE. **A record breaking low ice cover over the Great Lakes during winter 2011/2012.**

A record breaking low ice cover occurred in the Great Lakes during winter 2011/2012 with a strong positive Arctic Oscillation/North Atlantic Oscillation (AO/NAO) and a La Nina event. Large-scale atmosphere circulation in Pacific and North America (PNA) region reflected a combined signal of La Nina and +NAO. Statistical analysis indicted that neither La Nina nor +NAO alone can be responsible for the extreme warming event; the typical mid-latitude response to La Nina events is a negative PNA pattern, which does not have a significant impact on the Great Lakes winter climate; the positive phase of NAO is usually associated with a moderate warming in the Great Lakes region. While the two occurred simultaneously, the combined effects of La Nina and +NAO results in an East Pacific pattern with a negative center over Alaska/west Canada and a positive center in south, and an enhanced positive center over the eastern and southern United States. The overall pattern prohibited the movement of the Arctic air mass into mid-latitudes and enhanced southerly flow and warm advection from the Gulf of Mexico over the eastern United States and Great Lakes region, leading to the extreme warm and a record breaking low ice cover during the 2011/12 winter. A very similar recent event occurred in the winter of 1999/2000. *Keywords: Atmosphere-lake interaction, Climate change, Ice.*

WANG, L.[1], SEELBACH, P.W.[2], BURROWS, M.[1], DEMPSEY, D.[3], BOEHME, J.[1], YUZYK, T.[4], LAITTA, M.[3], RISENG, C.M.[5], RUTHERFORD, E.S.[6], MASON, L.A.[5], and WEHRLY, K.E.[7], [1]International Joint Commission, Great Lakes Regional Office, 100 Ouellette Ave, Windsor, ON, N9A 6T3; [2]USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105-2807; [3]International Joint Commission, U.S. Section, 2000 L Street NW, Washington DC, DC, 20036; [4]International Joint Commission, Canadian Section, 234 Laurier Ave W, Ottawa, ON, K1P 6K6; [5]School of Natural Resource and Environment, University of Michigan, 440 Church Street, Ann Arbor, MI, 48109; [6]NOAA-GLERL, 4840 S. State Rd, Ann Arbor, MI, 48108; [7]Institute for Fisheries Research, 1109 N. University, Ann Arbor, MI, 48109. **Great**

Lakes Information Integration Needs and Approaches for Meeting Objectives of the Water Quality Agreement and Other Management Challenges.

Achieving the objectives of Great Lakes (GL) Water Quality Agreement (WQA) and making effective management decisions requires consistent basin-wide information that is integrated across management needs and spatial scales. The many efforts to collect, assemble, manage, and deliver GL environmental data are largely grant funded and designed to achieve specific objectives for specific locations with narrowly defined deliverables. Those efforts do not meet the GLWQA and effective basin-wide management needs. The GL Aquatic Habitat Framework (GLAHF) project can potentially meet the data integration needs by providing spatial linkages among tributary watersheds, 30x30m cell size costal/nearshore, and 1.8x1.8km cell size offshore zones. These spatial units are attributed with all available physical, chemical, biological, and social economic information allowing users to "zoom in" to manage specific problems at specific locations and to "zoom out" to identify overarching issues for effective policy making. However, GLAHF needs broader participation from Canada and US, and needs to be linked with long-term supported information delivery systems. Hence, we call for government agencies, academia, and NGOs to form a joint force to guide and coordinate efforts of GL basin-wide information spatial linkage, integration, and delivery. *Keywords: Great Lakes basin, Ecosystems, Assessments.*

WANG, L.L.[2], CHERKAUER, K.A.[2], and FLANAGAN, D.C.[2], [1]225 South University street, West Lafayette, IN, 47906; [2]224 South University street, West Lafayette, IN, 47906. **the Impact of Climate Change on Soil Erosion in Great Lakes Region.**

Quantifying changes in potential soil erosion under projections of changing climate is important for the sustainable management of land resources, especially for regions dominated by agricultural land use. One of the expected changes to climate in the future is an increase in the frequency and intensity of rain events. The recently developed VIC-WEPP (Variable Infiltration Capacity - Water Erosion Prediction Project) coupled model was utilized to quantify changes in potential soil erosion by water under three climate change scenarios (a1b, a2b, b1) using projections from three global climate models (GFDL, PCM, HadCM3) for the Great Lakes region. Soil loss estimates were developed for thirty year periods for the current century, and compared to estimates for a thirty year historical period. Relative changes in precipitation, freeze-thaw state of the soil, snow cover and other hydrologic metrics were used to explain changes in erosion potential, and regions with large projected changes in erosion risk were identified. The results may be useful for targeting future erosion control efforts and/or conservation funding. *Keywords: Climate change, Soil Erosion, Sediments.*

WANG, X.X., LIAO, Q., and LI, J., University of Wisconsin Milwaukee, Milwaukee, WI, 53211. **Numerical Modeling of Wave-induced Beach Ground Water Flow and Biocolloid Transport in Sandy Beach.**

This research is based on a hypothesis that the sandy beach could be a sink and source of microbial pollutant. We contend that beach ground water flow mechanisms are key to quantify the rate at which suspended biocolloids enter the beach sand and their subsequent transport and fate within the sand matrix. There are three numerical models in this project. First, we developed a wave numerical model to simulate the surface water flow in the swash zone. Second, a saturated groundwater flow model is developed to simulate the percolation of pore water within a sandy beach driven by varying tidal levels and swash motions. Third, with the results from the previous model we add a concentration model to quantify the flux rate of biocolloid transport in the beach water interface. In addition We have conducted field experiments in order to investigate mechanisms that govern the fate and transport of bio-colloids, e.g., viruses, bacteria and protozoa, in a typical swash zone of Lake Michigan. The methods and instruments used in the field experiment included conducting a video-imaging based wave gauges, LPIV(large particle PIV), pressure transducers and ADV and bacterial sampling. The measured data were used to drive and validate the models. Eventually, modeled results are used to evaluate the transport of bio-colloids in the sandy matrix. *Keywords: Coastal engineering, Environmental effects.*

WÄNGBERG, S.A.[1] and DROTZ, M.K.[2], [1]University of Gothenburg, Dept. Plant and Environmental sciences, Gothenburg, SE-405 30, Sweden; [2]Lake Vänern Museum, Lidköping, SE-531 54, Sweden. **Biodiversity in Lake Vänern - a large lake in northern Europe - qualities and threats.**

Lake Vänern, with an area around 5500 km2, is the largest lake in Western Europe. Its location and size gives the lake a maritime character with unique fauna and flora elements. Around 300 000 inhabitants lives around the lake and have it as its freshwater source. The lake is the largest water power regulation dam in Sweden with a volume of 153 km^3, and it is commercially used both for transport and for fishing. The lake is also important for recreation both for tourists and for those living in the area. Not all this usages of the lake are without conflicts. Pollution by nutrients and toxic substances has historically been important factors that have structured the biological communities. These contaminations have decreased significant but are still not unimportant, at least locally. New factors are affecting the ecosystems in Lake Vänern are coupled to climate change - new hydrographic conditions, less ice and changed composition of incoming waters - and changed regimes for the water level control - reduced erosion makes that shores are becoming overgrown with bushes and trees.
Keywords: Biodiversity, Lake Vänern, Water level fluctuations, Plankton.

WAPLES, J.T.[1], KLUMP, J.V.[1], and ORLANDINI, K.A.[2], [1]School of Freshwater Sciences, 600 E. Greenfield Ave., Milwaukee, WI; [2]Argonne National Laboratory, Argonne, IL. **Measuring particle flux in the nearshore: What are sediment traps and radiotracers telling us?**

Here we examine a decade of data relating to the flux of particles in nearshore Lake Michigan. Particle fluxes derived from measurements of thorium-234 (half life: 24.1 days) and yttrium-90 (half life: 2.7 days) are compared to sediment trap measurements and discussed in relation to physical and biological processes including thermal stratification, seiche activity, the thermal bar, resuspension, and benthic filter feeding. *Keywords: Radioisotopes, Sediment resuspension, Lake Michigan.*

WARNER, D.M., BUNNELL, D.B., CHRISCINSKE, M.A., KELLER, K., and O'MALLEY, B.P., USGS Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI, 48105. **Is *Mysis diluviana* Abundance Controlled by Top-Down Forces?**

Mysis diluviana is an important part of the food web in all of the Laurentian Great Lakes except Lake Erie. While it has historically been an important food item for fish, recent declines in *Diporeia* spp. may have resulted in even greater predation pressure on *M. diluviana*. It is unclear how food web changes have affected this species and whether or not additional predation would lead to declines in *M. diluviana* abundance. In this study of *M. diluviana* in lakes Michigan and Huron, we examined lakewide late-summer abundance and distribution over several years to determine whether long-term changes have occurred. We then provide more detailed analysis in 2007 and 2010, when we had seasonal estimates of *M. diluviana* abundance and production. Finally, in 2007 and 2010 we compared *M. diluviana* production from size-frequency data to bioenergetic estimates of consumption of *M. diluviana* by fish, based on seasonal fish diet information, both field and literature estimates of fish growth rates, and acoustic and bottom trawl estimates of fish density. Our analyses will provide considerable insight into how the changing food webs have affected *M. diluviana*. *Keywords: Bioenergetics, Acoustics, Lake Michigan.*

WATKINS, J.M.[1], RUDSTAM, L.G.[1], SCHANER, T.[2], and CONNERTON, M.[3], [1]Cornell Biological Field Station, 900 Shackelton Pt Rd, Bridgeport, NY, 13030; [2]OMNR, Rural Route #4, Picton, ON, K0K 2T0; [3]NY State Department of Environmental Conservation, Lake Ontario Unit, PO Box 292 541 E Broadway, Cape Vincent, NY, 13618. **Spatial Patchiness of Nighttime Distribution of *Mysis diluviana* Across Light and Temperature Regimes in Lake Ontario.**

The opossum shrimp *Mysis diluviana* is a central component of the Lake Ontario foodweb as a prey for fish and predator on zooplankton. Annual late-summer OMNR-NYDEC nighttime hydroacoustic (120 kHz) surveys from 2005-2009 and 2011-2012 track the vertical distribution of *Mysis diluviana* and forage fish across Lake Ontario. The seasonal timing of these surveys coincides with peak stratification and the presence of a strong deep chlorophyll layer (DCL). Midlake water column profiles from August EPA GLNPO surveys track the depth and

intensity of the DCL that follows the eastward descent of the thermocline set up by prevailing winds. Satellite imagery detects lakewide variation in water clarity and localized upwelling that commonly occurs in the northwest. The five north-south hydroacoustic transects sample a broad variation in thermocline depth and water clarity. We compare the observed depth of mysis populations to predictions from published distribution models based on temperature, light, and predator avoidance. We also assess whether spatial patterns in abundance are repeated across years and reflect gradients in bathymetry, hydrodynamics, or primary productivity.
Keywords: Mysis, Spatial distribution, Lake Ontario.

WATSON, N.M., ARMENIO, P.M., BUNNELL, D.B., DAVIS, B.M., and O'MALLEY, B.P., 1451 Green Rd, Ann Arbor, MI, 48105. **The Effect of *Bythotrephes longimanus* Predation on the Diel Vertical Migratory Patterns of Cladocera Offshore of Hammond Bay, Lake Huron.**

The introduction of the planktivore *Bythotrephes longimanus* in the mid-1980s resulted in a decline in cladoceran populations, both in overall numbers and species richness. As cladocerans are a primary food source for larval, juvenile, and adult planktivorous fishes, this decline in cladoceran productivity could have negative consequences for fish recruitment. Collections were performed both day and night at two depths, 46 and 82m, offshore of Hammond Bay, Lake Huron. We used a closing, 64-micron mesh plankton net to sample the epilimnion, metalimnion, and hypolimnion, both upper and lower levels at the 82m depth, monthly from April through October. We will evaluate whether cladocerans and other zooplankton alter their depth distribution in the water column in response to the presence of *Bythotrephes*. *Keywords: Bythotrephes longimanus, Lake Huron, Cladocera.*

WECKERLY, K.M., SZMANIA, D.N., KLUMP, J.V., and WAPLES, J.T., School of Freshwater Sciences, 600 E. Greenfield Ave., Milwaukee, WI. **The dynamics of particle and phosphorus loading to the Milwaukee River from rural, suburban, and urban sub-watersheds.**

Here we examine how particle and phosphorus loading to the Milwaukee River varies as a function of watershed development in rural, suburban and urban areas. We constrain watershed yields and examine watershed particle transport speeds in relation to seasonal and episodic (wet versus dry) events using radionuclides lead-210 and beryllium-7. *Keywords: Watersheds, Sediment load, Radioisotopes.*

WEICKSEL, S.[1], LUPI, F.[1], CHEN, M.[1], and KAPLOWITZ, M.[2], [1]Dept of Ag, Food, and Resource Economics, Michigan State University, East Lansing, MI, 48824-1039; [2]CARRS, Michigan State University, East Lansing, MI, 48824. **What's in a Name? Labeled Versus Unlabeled Choice Experiments for Valuing Great Lake Beach Characteristics.**

Beach going is among the most popular recreational uses of the Great Lakes (GL), yet beaches face many threats and little is known about the economic value of water quality at beaches. We surveyed 5600 Michigan residents who visited GL beaches in 2011. We elicited preferences for beach attributes using a choice experiment where respondents choose between beaches with varying levels of attributes (levels of algae, E.coli testing, etc.) and economic cost (driving distance). Not surprisingly, we found respondents significantly prefer beaches that are closer to home, tested frequently for bacteria, and have less algae on the shore and in the water. People were also more concerned about algae in the water than on the shore. With a split sample design, we tested if explicitly naming ("labeling") the Great Lake associated with beaches in the choice experiment (e.g., a "Lake Michigan beach") affected trade-offs people were willing to make among cost and water quality. We find that with or without GL name labels, the trade-off results are similar. Managers can use the findings to predict the benefits of quality improvements or damages caused by declines in beach quality. To develop the survey and experiment we involved EPA GLNPO, NOAA GLERL, Sea Grant, MI Dept of Environmental Quality, County health officials and beach managers. *Keywords: Ecosystem modeling, Economic evaluation, Algae.*

WELLEN, C. and ARHONDITSIS, G.B., University of Toronto, 1265 Military Trail, Toronto, ON, M1C 1A4. **On the (extreme) benefits of being a Bayesian watershed modeler: lessons learned in Hamilton Harbour.**

Watershed models are routinely used to dictate policy, yet cannot be relied upon uncritically. Our work in Hamilton Harbour has demonstrated a Bayesian approach to model calibration which can address many of the shortcomings of contemporary modeling practice. We have developed Bayesian calibration approaches which allow us to accommodate the sometimes extreme variations in pollutant export at annual and daily timescales by allowing the parameters to vary with time, while estimating the uncertainty from all the sources typically associated with watershed modeling. We apply these frameworks to simple (SPARROW) and complex (SWAT) models and use them to estimate pollutant loads and sources at a variety of temporal and spatial scales along with their associated uncertainties. We conduct numerical experiments to evaluate field sampling protocols. Our results suggest that i) phosphorus export varies substantially at annual timescales, while at daily timescales large events delivered a disproportionate amount of total load; ii) although agricultural areas exported more phosphorus than urban areas at annual timescales, agricultural phosphorus export was muted during the growing season and urban phosphorus export was unabated; and iii) event-based sampling protocols were required to arrive at the most credible estimates of loads. *Keywords: Mathematical models, Bayesian inference, Ecosystem modeling, Model testing.*

WELLER, J.D. and CHOW-FRASER, P., Department of Biology, McMaster University, 1280 Main St. West, Hamilton, ON, L8S 4K1. **Long-Term Changes to Muskellunge (*Esox masquinongy*) Nursery Habitat in Georgian Bay, Lake Huron: Implications for Habitat Availability.**

In 1981, twenty coastal wetlands in Severn Sound (SS), Georgian Bay (GB) were surveyed and found to have young-of-the-year (YOY) muskellunge (*Esox masquinongy*). In 2012, we repeated the survey method in 16 sites, and could not find any YOY. We hypothesize that the absence of YOY is due to loss of critical nursery habitat as a result of water-level declines and shoreline alterations. Satellite imagery and historic air photos were obtained for 7 time periods between 1931 to 2009, which included both low and high water-level scenarios. For each site, we delineated available aquatic habitat and calculated dock density (#docks per shoreline length (km)). Data before and after 1981 were grouped and compared; mean dock density was significantly higher in the latter period. We also found a significant decline in cover of submerged aquatic vegetation (SAV) with declining water levels. We suggest that the absence of YOY in recent times in Severn Sound is due to loss of aquatic habitat because of low water levels as well as the negative impact of increased dock densities. We contrast these results to another study being carried out in Beaverstone Bay, where there has not been any significant increase in dock density, and where YOY are still found during a 2012 survey.
Keywords: Georgian Bay, Muskellunge, GIS, Nursery habitat, Coastal wetlands.

WHEELER, R.L. and UZARSKI, D.G., 2625 Denison Drive, Lab 123, Central Michigan University, Mount Pleasant, MI, 48859. **Spatial Variation of Macroinvertebrate Communities within Two Emergent Plant Zones of Great Lakes Coastal Wetlands.**

Great Lakes coastal wetland assessment and monitoring has received considerable attention recently due to the recognition of the importance of these systems in maintaining the overall health of the Great Lakes ecosystem. As a result, the demand for detailed research focusing on the ecological processes and interactions within Great Lakes coastal wetlands has increased. Past research has described the changes in macroinvertebrate communities within Great Lakes coastal wetlands through a gradient of abiotic conditions from upland through the emergent wetland to true aquatic, or submersed aquatic habitats. However, spatial variation of macroinvertebrate community characteristics within a given zone along this gradient is less understood. This study explores the spatial variation of macroinvertebrate communities within two types of Great Lakes coastal wetland plant zones. The results suggest relationships between macroinvertebrate communities and spatial variation that are relevant to current and future assessment and monitoring efforts in Great Lakes coastal wetlands. *Keywords: Coastal wetlands, Macroinvertebrates, Spatial distribution.*

WHITE, T.J., 42 W. Warren Ave., Detroit, MI, 48202. **The Effects of Phragmites australis Litter Cover on Seed Germination in Great Lakes Coastal Wetlands.**

The invasive reed, *Phratmites australis*, is widely dispersed within the Great Lakes region. Once established, it is known to create dense litter mats that may persist even after remediation efforts to remove living stocks have been implemented. Although much is known about the ability of *P. australis* to displace native plants, accumulate biomass and its decomposition rates, little work has been done on its potential impact to the native seed bank. In this greenhouse study, we investigated the effects of *P. australis* and *Typha angustifolia*, narrow-leaf cattail, litter on seed germination. We harvested soils from five Great Lakes coastal wetland habitats within the Detroit River corridor that were densely populated by *P. australis or T. angustifolia* and exposed them to either *P.australis or T. angustifolia* litter in treatments of varying litter depths. Germinations were quantified daily for six weeks. Using log-linear analysis, we found that soils in *P. australis* dominated habitat have significantly less seed germinations regardless of litter cover depth. Depth of litter cover significantly impacted the number of germinations observed regardless of litter species or site soil. There were no species-specific effects of litter type on the number of germinations observed. *Keywords: Invasive species, Phragmites, Coastal wetlands, Seed-bank, Detroit River.*

WIETSMA, T.[1], MINSKER, B.[1], and COLLINGSWORTH, P.C.[2], [1]University of Illinois at Urbana-Champaign, Urbana, IL; [2]Illinois-Indiana Sea Grant, Chicago, IL. **Improving Limnological Sampling Campaigns Through Real-Time Signal Processing and Machine Learning.**

Working with the Illinois-Indiana Sea Grant and the Environmental Protection Agency, we investigate historical sample data from the Great Lakes generated by multiple field technicians over more than a decade. Data includes high-frequency depth profiles for multiple variables and the locations (depths) from which samples were collected for laboratory analysis. By applying signal processing and machine learning techniques to the digital downcast data, characteristic features can be automatically extracted in real time. Such features of interest include the thermocline, deep chlorophyll maximum, and mixed-layer bounds. We present these feature extraction techniques as a tool to assist field technicians in future wet-chemistry sampling. We also demonstrate that by relating these features to historical depths used for wet chemistry sampling, machine learning-based methods can yield generic sampling policies that are consistent with previous efforts. Future research, including the opportunity for interactive models to assist technicians, are discussed. *Keywords: Data acquisition, Machine learning, Signal processing, Adaptive sampling, Control systems.*

WIJESINGHE, R.U.[1], OSTER, R.J.[1], FOGARTY, L.R.[1], ISAACS, N.[1], TUCKER, T.R.[2], and RILEY, S.[2], [1]USGS- Michigan Water Science Center, 6520, Mercantile Way, Suite 5, Lansing, MI, 48911; [2]USGS-Great Lakes Science Center, 451 Green Rd, Ann Arbor, MI, 48105.
Detection and quantification of type E toxin gene () in spp. at Great Lakes beaches.kw__iaglrkey

Clostridium botulinum type E toxin is believed to be responsible for the death of thousands of birds and fish in the Great Lakes. Previous studies have suggested that *Cladophora* mats may support the survival and persistence of *Clostridium* species. This study was conducted to determine the concentration of *C. botulinum* type E at 10 beaches found along Lake Michigan, Lake Erie, Lake Superior and Lake Huron, where *Cladophora* was present. A total of 150 *Cladophora* samples were collected from 10 beaches in Michigan, Ohio, Indiana, Wisconsin and Illinois from June 2012 to November 2012. qPCR was used to quantify the *bontE* gene of *C. botulinum*, which is responsible for the production of type E toxin. In addition, 74 sediment and 37 water samples were also evaluated to determine if the gene was present in different matrices. The *bontE* gene was detected most frequently in *Cladophora* at Jeorse (Lake Michigan) and Bay City (Lake Huron) beaches. Furthermore, *Cladophora* mats may provide better ecological niches for the persistence of *C. botulinum* than other matrices. Ultimately, quantitative assessment of *bontE* gene is important for understanding the distribution of these bacteria in different matrices and different geography. *Keywords: Algae, , Microbiological studies, Environmental health.*

WILEY, M.J.[1], RISENG, C.M.[1], RUTHERFORD, E.S.[2], and PIJANOWSKI, B.C.[3], [1]University of Michigan, Ann Arbor, MI, 48109; [2]NOAA-GLERL, Ann Arbor, MI, MI; [3]Purdue University, West Lafayette, IL. **Land use tipping points in Midwestern streams.**

Much of the Great Lakes watershed has experienced rapid changes in land use and land cover over the past three decades, and these changes have had substantial impacts on the hydrology and ecological integrity of its rivers and streams that drain to the Great Lakes. We developed normalized metrics of biological condition for over 4,000 sampled river segments in Michigan, Wisconsin and Illinois. We related these metrics of biological conditions with landscape stressors in Regression Tree models to identify levels of watershed and buffer developed land use that represent tipping points for river ecosystems. *Keywords: Ecosystem forecasting, Great Lakes basin, Indicators.*

WILLIAMS, K.C., University of Wisconsin-Milwaukee, Department of Geography, Milwaukee, WI, 53211. **Nurturing a Sense-of-Place: New Pathways for Participation in Great Lakes Areas of Concern.**

The International Joint Commission and the US Environmental Protection Agency have directed that public input is a critical component of the delisting process in the Great Lakes Areas of Concern (AOC). As a result, organizations and agencies are looking beyond the traditional methods of inviting stakeholders and the public to participate in the AOC process. In some AOCs, organizations have begun to develop and implement educational activities rooted in

developing a "sense-of-place." Using a comparative case study approach, place-based educational activities were identified in the St. Louis Estuary, Milwaukee Estuary and St. Marys River AOCs. Data about activities were collected through participant observation and interviews. Initial results indicate organizations and educators hope to replace the sense that the rivers of the AOCs are polluted sites to be avoided, with a connection to the rivers. This connection would transform the rivers from invisible or degraded areas into "centers of felt value (Tuan, 1977)." This study concludes with a discussion of how place-based educational principles and activities can be applied directly to Beneficial Use Impairment (BUI) removal through a study of how the Degradation of Aesthetics BUI has been approached in each of the three AOCs.
Keywords: Political aspects, Public participation, Non-governmental organizations.

WILLIAMS, M.C., MSU Dept. of Fisheries and Wildlife, 480 Wilson Road, Room 13 Natural Resources Building, East Lansing, MI, 48824. **SPATIAL, TEMPORAL, AND COHORT-RELATED PATTERNS IN THE CONTRIBUTION OF WILD CHINOOK SALMON (*ONCORHYNCHUS TSHAWYTSCHA*) TO TOTAL CHINOOK HARVEST IN LAKE MICHIGAN.**

During 2006-2010, the majority of hatchery-produced Chinook salmon (*Oncorhynchus tshawytscha*) stocked into Lake Michigan were marked with a combination of oxytetracycline (OTC), coded-wire-tags (CWT), and fin-clips to distinguish between hatchery and wild origin. The goals were to: (1) evaluate the accuracy and reproducibility of the OTC mark, (2) examine spatial, temporal, and cohort-related patterns in the contribution of wild Chinook salmon, and (3) explore how differences in size-at-age and maturity-at-age may affect the proportion of wild Chinook salmon. OTC mark accuracy and reproducibility was determined to be adequate based on error matrix fish, OTC mark quality distribution, and OTC mark presence/absence reader agreement was excellent. The lakewide proportion of wild age-1 Chinook salmon for four year-classes ranged from 53.52 to 56.92% with little interannual variation. The proportion of wild Chinook salmon increased as the fish became older (i.e., age-effect), suggesting differential survival between hatchery and wild fish. The proportion of wild age-1 Chinook salmon was greater in Michigan than Wisconsin, but was similar for older ages. The proportion of wild Chinook salmon in the northeast, northwest, and southwest regions all had an age-effect, however, the southeast region did not have an age-effect. *Keywords: Lake Michigan, Natural reproduction, Salmon, Lake management.*

WILSON, A.E.[1], STEIN, S.R.[2], GRIMM, E.F.[3], ROSWELL, C.R.[2], JAMEEL, M.Y.[4], TROY, C.D.[3], BOWEN, G.[4], and HÖÖK, T.O.[2], [1]Department of Fisheries and Allied Aquacultures, Auburn University, Auburn, AL, 36849; [2]Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN; [3]School of Civil Engineering, Purdue University, West Lafayette, IN; [4]Department of Geology & Geophysics, University of Utah, Salt Lake City, UT.
Do rivers mediate water quality in nearshore areas of Lake Michigan?

Rivers serve as important conduits for nutrients and organisms. Although discharge varies over space and time, rivers are generally expected to have important effects on the

ecosystem-level properties of nearshore areas. To test this assumption, we intensively monitored water quality parameters in three important rivers that varied widely in chlorophyll (20-101 ug/L) and nutrients (TN=1000-3600 ug/L; TP=81-106 ug/L)), including Trail Creek, St. Joseph, and Muskegon, and connected nearshore areas in Lake Michigan. Standard epilimnetic samples and physicochemical data were collected for one site in each river ("rivermouth") and 5 sites outside of each rivermouth ("lake") 1-2x per month from May-Oct in 2011-2012. Lake data were pooled for each date. Monthly averaged data were used for statistical analyses. As expected, rivermouths were generally more productive than lake sites as measured by all water quality parameters, including Secchi, chlorophyll, TP, TN, and TSS (paired t-test $P < 0.0001$). Interestingly, we found no significant correlations between rivermouth and lake sites for any parameter when analyzing all three rivers together and few clear relationships for river system-specific correlations. These findings suggest that the effect of rivers on water quality of nearshore areas may be weak for large lakes. *Keywords: Lake Michigan, Nutrients, Water quality.*

WILSON, G.B.[1] and HEATH, R.T.[2], [1]The Ohio State University, 376 West 10th Avenue, Columbus, OH, 43210; [2]Kent State University, P.O. Box 5190, Kent, OH, 44242. **Even the Experts Don't Always Agree: Findings from an EBM Survey.**

A holistic, integrated management approach has been adopted in many large aquatic ecosystems. A survey-based approach was used to assess characteristics of implementation of the ecosystem approach (EA)/ecosystem-based management (EBM) in Lake Erie and four reference aquatic systems: Chesapeake Bay, Puget Sound, Tampa Bay and the Baltic Sea. To understand differences in perceptions of diverse stakeholders, survey respondents were stratified in two ways: by area of focus (Aquatic, Fisheries, Watershed and Ecosystem) and by type of organization (Government/Regulatory, Business/Industry, Academic and NGO). Three analyses were performed on the data: comparison across the five ecosystems (Analysis A), stratification and comparison of Lake Erie stakeholders by area of focus and type of organization (Analysis B), and stratification and comparison of all ecosystem stakeholders by area of focus and type of organization (Analysis C). Stakeholder perceptions versus realities in Lake Erie and reference aquatic ecosystems were analyzed regarding EA/EBM implementation, voluntary versus legislatively mandated implementation, ecosystem condition, perspectives of diverse stakeholders, public engagement and leadership organizations. Similarities and differences in perceptions by diverse ecosystem stakeholder "experts" will be highlighted.
Keywords: Ecosystem health, Great Lakes basin, Lake Erie.

WILSON, R.S., The Ohio State University, 210 Kottman Hall, 2021 Coffey Rd, Columbus, OH, 43221. **Nutrient Loss and Water Quality: A Survey of Farmer Values, Attitudes and Beliefs in the Maumee Watershed.**

Non-point source runoff from agricultural production is projected to worsen with climate change, as more intense rains transport more nutrients downstream. To combat these problems, agricultural best management practices (BMPs) have been advocated, but policymakers have been reluctant to mandate these and voluntary farmer adoption has proven insufficient. Using the western Lake Erie Basin as a model ecosystem, we conducted a mail survey of conventional corn-soybean farmers to develop a farmer decision-making model as part of a larger coupled human-natural system model. Preliminary results indicate that farmers are willing to take additional action when they 1) are concerned, 2) value societal over individual goals, and 3) believe that nutrient loss is likely to result in negative consequences (i.e., high perceived risk). Farmers who are more profit-driven in their farming goals are more likely to take action when they believe in the effectiveness of BMPs. Outreach focused on increasing adoption should target risk and efficacy-based beliefs among the majority (~70%) of farmers who are willing to take action. For those who are slightly less willing to take action, structural policies (e.g., incentives) may be a more effective means of increasing adoption, in particular for those with extensive rented acreage. *Keywords: Water quality, Communication, Decision making, Human behavior, Public education, Risk perception.*

WINSLOW, C.J.[1], THOMPSON, T.[2], BUCKLEY, J.T.[3], and THOMAS, M.A.[4], [1]1314 Kinnear Rd, Ohio State University, Columbus, OH, 43212; [2]2560 Key Street Apt 4R, Toledo, OH, 43614; [3]146 Brooks Hall, Central Michigan University, Mount Pleasant, MI, 48859; [4]PO Box 119, OSU's Stone Laboratory, Put-In-Bay, OH, 43456. **Hypoxia in a Shallow System: What Causes Low Dissolved Oxygen in the Western Basin of Lake Erie.**

Scientists have previously assumed that thermal stratification and hypoxia (dissolved oxygen (DO) ≤2.0ppm) rarely occur in the Western Basin of Lake Erie (WBLE). Hence, little attention has been given to the impact of hypoxia on foraging/distribution of organisms in this productive region. Yet researchers at Ohio State's Stone Lab have detected low DO and changes in fish dispersion. To quantify the spatial and temporal occurrence of stratification and hypoxia we deployed probes around the Bass Islands in the WBLE. Four buoys recorded DO hourly near the lake bottom while all buoys measured temperature throughout the water column. We also analyzed weather and sediment oxygen demand (SOD) to determine if oxygen reduction could be explained by bacterial activity and infrequent mixing. Hypoxia was detected 17% of the time, at all sites, and from early July-September. Hypoxia was detected during stratification but also occurred when water was not stratified. Sediment analysis indicates that SOD can deplete oxygen but not at rates recorded by probes. We suggest that subsurface water masses moving through the basin, in the absence of vertical mixing, may explain hypoxia. Our research highlights a need to monitor hypoxia in shallow systems, investigate water mass movements, and assess impacts on fish movement and survivorship. *Keywords: Benthos, Hypoxia, Bottom currents, Shallow, Lake Erie, Dissolved oxygen.*

WITHERS, J.L.[1], FOLEY, C.J.[1], TROY, C.D.[2], and HÖÖK, T.O.[1], [1]Department of Forestry and Natural Resources, Purdue University, 195 Marsteller Street, West Lafayette, IN, 47907; [2]School of Civil Engineering, Purdue University, 550 Stadium Mall Drive, West Lafayette, IN, 47907.
Larval yellow perch, larval alewife, predatory zooplankton, and their potential prey within near-shore southeastern Lake Michigan: Potential for competition?

Yellow perch and alewife are ecologically and economically important species in Lake Michigan; however, a full understanding of mechanisms controlling early life survival and subsequent recruitment of both species is lacking. Both species spawn, hatch, and presumably begin first-feeding in the nearshore region, where they co-occur with three species of predatory zooplankton, Leptodora kindtii, Bythotrephes cederstroemi, and Cercopagis pengoi. These species consume small zooplankton prey and are therefore hypothesized to compete with first-feeding larval fish for prey resources. During 2010-2011, we indexed environmental conditions and examined spatiotemporal distributions of larval fish, predatory zooplankton, and their potential prey in a nearshore region of Lake Michigan. We generated production and consumption estimates to compare potential demand of predatory zooplankton and larval fish with available zooplankton. We documented high spatiotemporal variability of environmental conditions, zooplankton prey, predatory zooplankton and larval fish. Predatory zooplankton appear to attain peak densities further off-shore or later in the year, relative to larval fish. Nonetheless, in our nearshore study area densities, biomasses and estimated consumption rates of Leptodora and Cercopagis frequently exceeded larval fish. *Keywords: Invasive species, Alewife, Lake Michigan, Yellow perch.*

WITTMANN, M.E.[1], COOKE, R.[2], ROTHLISBERGER, J.[3], RUTHERFORD, E.S.[4], ZHANG, H.[5], MASON, D.M.[5], and LODGE, D.M.[1], [1]University of Notre Dame, Notre Dame, IN, 46556; [2]Resources for the Future, Washington, D.C., 20036; [3]U.S. Forest Service, Milwaukee, WI, 53202; [4]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI, 48108; [5]Cooperative Institute of Limnology and Ecosystems Research, University of Michigan, Ann Arbor, MI, 48109. **Using Structured Expert Judgment to Quantify the Impact of Asian Carp (Bighead and Silver) on Lake Erie Fishes.**

Natural resource managers are often required to make important decisions despite great uncertainties about the risks posed by environmental stressors. Because the implications of uncertainty on decision-making are well known, the need to quantify uncertainty, particularly with respect to complex environmental problems, is a necessary task in the science and practice of aquatic conservation. In this study, we used expert elicitation (using the Classical Model, see Cooke 1991) to quantify the future impacts, with uncertainty, of invasive Asian carp (silver and bighead) establishment on the Lake Erie food web. Expert quantifications of Asian carp peak biomass in Lake Erie ranged from zero to greater than 25 metric tons per kilometer squared. Performance based weighted results suggested positive impacts to Lake Erie yellow perch biomass, but negative impacts to Lake Erie walleye, gizzard shad, and rainbow smelt biomass as a result of Asian carp invasion. We also report on experts' rationale of mechanisms supporting quantitative uncertainty estimates. *Keywords: Ecosystem forecasting, Carp, Biological invasions.*

WOOD, N.J., GEHRING, T.M., and UZARSKI, D.G., Central Michigan University, Biology Department, Mount Pleasant, MI, 48859. **A Deeper Look Into the Invasive Mute Swan's Impact on the Coastal Wetlands of Michigan.**

Mute swans (*Cygnus olor*) are a native species from Europe that have been introduced several times to North America (Ciaranca et al., 1997; Allin et al., 1987). Great Lakes populations have increased at a rate of 10-18% annually, resulting in a Michigan mute swan population estimated at 15,500 individuals in 2010 (Petrie & Francis, 2003; MDNR, 2012). Mute swans are tremendous consumers of their preferred food, submerged aquatic vegetation (SAV) (Allin & Husband, 2003). A reduction in SAV not only impacts food resources for other bird species, but it impacts habitat resources for small fish and invertebrates (SFI). SAV and SFI sampling occurred in September 2012 in the drowned river mouth lakes along the eastern shore of Lake Michigan. Transects were drawn through each SAV bed and a throw trap was placed at three different depth intervals. All the SAV in the trap was removed and frozen for future analysis. Fish were seined from the trap, identified and measured. Abiotic data was also collected from each SAV bed. Lakes with large mute swan populations showed a stunting of blue gill lengths when compared to lakes with little or no mute swans present. The abiotic data also separated along the mute swan variable. These initial analyses have shown that mute swans may be negatively impacting the coastal wetlands in Michigan. *Keywords: Invasive species, Wetlands, Avian ecology*.

XIA, M.[1], SCHWAB, D.J.[2], and MAO, M.[1], [1]University of Maryland Eastern Shore, Department of Natural Sciences, 1 Backbone St, Princess Anne, MD, 21853; [2]University of Michigan, Graham Environmental Sustainability Institute, Ann Arbor, MI, 48109. **Understanding nearshore circulation using a coupled Lake Michigan and Grand Haven nearshore wave-current based model.**

It is widely known that nearshore water is the important region in Great Lakes and ocean. A high-resolution unstructured grid model is required, however it would be time-consuming if applying a high-resolution model in whole lake. Unlike coastal ocean, lake circulation significantly influences nearshore and coastal circulation. Additional local phenomenaes (e.g., wave) also need be included in nearshore model and it requires additional time to simulate these processes using lake scale model. So a couple lake and nearshore model is critical for nearshore dynamics at lakes. The nesting system between low-resolution Lake Michigan model and Grand Haven high-resolution one using Finite Volume Coastal Ocean Model (FVCOM) demonstrated the successful understanding of the nearshore dynamics. Forced by Lake Model, the Grand Haven model is coupled with wave model or FVCOM-SWAVE. The effect of waves on nearshore circulation and velocity fluctuations were simulated and calibrated with help of observational ADCP data. It was concluded that among the processes that wave effects present to the system, radiation stress and current-wave interaction are more important than wave-induced bottom stress. In additional, river discharge and ambient flow have little influence on nearshore circulation, while they interplay with wave forcing at coasts. *Keywords: Waves, Coastal processes, Lake Michigan.*

YIN, X.[1], HAWLEY, N.[2], and BELETSKY, D.[1], [1]CILER, 4840 S. State Road, Ann Arbor, MI, 48108; [2]GLERL, 4840 S. State Road, Ann Arbor, MI, 48108. **Measurements of the Ice Thickness in Lake Erie 2010-2011.**

Six instrumented moorings were deployed in the central basin of Lake Erie to make measurements of ice thickness during the winter of 2010-2011. Shallow water ice profilers (SWIPS) units were deployed in conjunction with acoustic Doppler current profilers (adcps) at 4 stations, while acoustic wave and current profilers (AWACs) were deployed at three stations. One station was instrumented with both a SWIPs and an AWACS so that comparisons between the two instruments could be made. Ice cover in the central basin began in the middle of January and continued until the end of March, but the cover was not continuous at any of the stations, and there was a notable thaw in mid-February when the ice cover all but vanished. The ice was highly fragmented, and ice thicknesses varied over a wide range at all of the stations (to over 5 m in some instances) as the ice floes rafted on top of each other. There is little correlation between the ice thicknesses at the different stations, and the thicknesses vary considerably over short (hours to days) time intervals. The instruments were deployed again during the winter of 2011-2012, but no ice was measured. *Keywords: Air-water interfaces, Ice, Lake Erie.*

YOUNG, E.B.[1], LEE, P.O.[1], and MCLELLAN, S.L.[2], [1]Dept Biological Sciences, University of Wisconsin-Milwaukee, Milwaukee, WI, 5321; [2]School of Freshwater Sciences, University of Wisconsin-Milwaukee, Milwaukee, WI, 53211. **Effects of Dreissenid Mussels and Benthic Algae on Benthic Bacterial Communities.**

Invasion of Laurentian Great Lakes by dreissenid mussels has caused dramatic changes to nutrient cycling and benthic-pelagic coupling, including stimulating benthic algal blooms and influencing food webs. Despite these impacts, there is limited data on benthic bacterial communities. This study aimed to examine effects of dreissenid mussels on benthic bacterial communities using experimental microcosms and genetic pyrosequencing. Microcosms mimicked Lake Michigan conditions with additions of mussels, benthic algae or both and controls with sediment only. Changes in water chemistry and sediment bacteria were monitored over 21 days. With mussels, water and sediment nitrate and SRP increased significantly. 383 bacterial genera were identified. Bacterial taxa which increased with mussels included Nitrospiraceae and Nitrosomonadaceae, involved in mediating N transformations. Bacterial abundance and taxonomic diversity increased in all treatments, but presence of mussels did not significantly increase bacterial diversity. However, benthic algae (*Cladophora*) did increase bacterial richness, suggesting a role for algae in providing habitat substrata as well as organic C to benthic bacteria. Changes in benthic bacterial communities associated with invasive mussels and benthic algae could influence nearshore nutrient cycling. *Keywords: Benthos, Pyrosequencing, Microbiological studies, Bacterial diversity, Dreissena.*

YOUSEF, F.[1], KERFOOT, W.C.[1], BROOKS, C.N.[2], SHUCHMAN, R.A.[2], SABOL, B.[3], and GRAVES, M.[3], [1]100 Phoenix Dr., Houghton, MI, 49931; [2]3600 Green Court, Suite 100, Ann Arbor, MI, 48105; [3]3909 Halls Ferry Road, Vicksburg, MS, 39180. **Using LiDAR to reconstruct the history of a coastal environment influenced by legacy mining.**

LiDAR (Light Detection and Ranging) data can be used to create fine digital elevation and bathymetric models (DEMs). Here we examine natural coastal erosion in Grand Traverse Bay, Michigan, a part of Keweenaw Bay in Lake Superior, and discuss how a variety of geological features (submersed river bed and channels associated with the Houghton Low; Nipissing dunes) interact with long-term sediment accumulation patterns. The combination of LiDAR derived images and aerial photographs allowed us to reconstruct the historical movement of tailings along the coastline. A total of 22.8 million metric tons (Mt) of stamp sand were discharged into the coastal environment off Gay, MI. Over a span of 80 years, beaches to the southwest of Gay have progressively received 7.0 Mt (30.7%) of the mass eroded from the original pile, whereas 11.1 Mt (48.7%) have moved into the bay. The total amount accumulated along the beaches now greatly exceeds the mass remaining on the original tailings pile (3.7 Mt; 16.2%). Bathymetric differences between two LiDAR surveys (2008 and 2010) were also used to estimate the mass, and to track the movement of migrating underwater stamp sand bars. These bars are moving southwesterly towards Buffalo Reef, creating a threat to the lake trout and lake whitefish breeding ground. *Keywords: Remote sensing, LiDAR, Lake Superior, Sediment transport.*

YUCUIS, R.A.[1], STANIER, C.O.[2], and HORNBUCKLE, K.C.[1], [1]Department of Civil & Environmental Engineering, IIHR-Hydroscience and Engineering, University of Iowa, Iowa City, IA, 52242; [2]Department of Chemical and Biochemical Engineering, University of Iowa, Iowa City, IA, 52242. **Cyclic Siloxanes in Air, Including Identification of High Levels in Chicago and Distinct Diurnal Variation.**

The organosilicon compounds octamethylcyclotetrasiloxane (D4), decamethylcyclopentasiloxane (D5), and dodecamethylcyclohexasiloxane (D6) are high production volume chemicals that are widely used in household goods and personal care products. Due to their prevalence and chemical characteristics, cyclic siloxanes have been targeted for study as possible persistent organic pollutants. Ambient air samples were collected in locations with varying population density in order to assess the potential impact of these compounds on humans and the environment depending on location type. Several indoor samples were also collected. The indoor concentrations were 10 to 100 times higher than outdoor measurements, with a median of 2200 ng m^{-3} for the sum of D4, D5, and D6. Outdoor sampling locations were in downtown Chicago, in Cedar Rapids, IA, and West Branch, IA, and had median sum siloxane levels of 280, 73, and 29 ng m^{-3} respectively. A diurnal trend is apparent in the samples taken in downtown Chicago. Nighttime samples had a median 2.7 times higher on average than daytime samples. D5 was the dominant siloxane in both indoor and outdoor air.
Keywords: Urban areas, Lake Michigan, Pollution sources.

YURISTA, P.M.[1], KELLY, J.R.[1], COTTER, A.M.[1], MILLER, S.E.[1], and VAN ALSTINE, J.[2], [1]US EPA Midcontinent Ecology Division, 6201 Congdon Blvd., Suluth, MN, 55804; [2]USDA Forest Service Kawishiwi Ranger District, 1393 Highway 169, Ely, MN, 55731. **Monitoring Landscape Influence on Nearshore Condition: Lake Michigan as Part of a Continuing Great Lakes-wide Study.**

A major source of stress to the Great Lakes comes from tributary and landscape run-off. The large number of watersheds and the disparate landuse within them create variability in the tributary input along the extent of the nearshore. Identifying the local or regional response to the impact of tributary and landscape run-off is difficult as input becomes incorporated into a dynamic nearshore system. We have been developing a monitoring strategy that correlates nearshore water quality with adjacent landscape characterization based on several broad categories of stress. We conducted a high-resolution survey of the Lake Michigan (1049 km) nearshore (approximate 20 m depth contour) using towed electronic instrumentation and fixed station sampling. We describe the variability of the nearshore region and show conditions are correlated with adjacent landscape. We make comparisons to offshore waters to identify the nearshore as a distinct region of the lake. Along shore tow surveys are an effective and efficient way to capture the character and condition of large expanses of coastal nearshore.
Keywords: Coastal ecosystems, Lake Michigan, Monitoring.

ZAQOUT, M. and DROUILLARD, K.G., Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, N9B 3P4. **Comparison of chemical kinetics in mussels and SPMDs using a consistent set of performance reference compounds.**

Mussel biomonitors and semi-permeable membrane devices (SPMDs) are commonly applied as samplers for water contamination of hydrophobic chemicals. Although past studies compared accumulation of contaminants between mussels and SPMDs placed along side of one another, few studies have corrected for differences in sampling rates between the two techniques. For SPMDs, performance reference compounds (PRCs) are added to the lipid matrix prior to deploying the sampler to correct for in situ sampling rates. Application of performance reference compounds in mussel biomonitors has only been recently reported. In this study, SPMDs and mussel biomonitors (Elliptio complanata) were dosed with a common set of 14 non-environmental PCB congeners used as PRCs. Mussels and SPMDs were deployed at 4 locations in the Detroit and St. Clair River during October-November 2011. Data on mussel PRC elimination were consistent in Kow trend with past biomonitoring studies but exhibited slower overall elimination due to cooler water temperatures. PRC elimination rates showed distinct differences between mussels and SPMDs, with more rapid time to steady state evident for mussels. Comparisons between environmental PCB composition measured in water from the two sampling systems following PRC-steady state correction of raw data are discussed.
Keywords: St. Clair River, SPMDs, Biomonitoring.

ZARRAONAINDIA, I.[1,2] and GILBERT, J.A.[1,3], [1]Argonne National Laboratory, 9700 South Cass Avenue, Lemont, Chicago, IL, 60439; [2]IKERBASQUE, Basque Foundation for Science, 48011, Balbao, Spain; [3]Dept. of Ecology and Evolution, University of Chicago, 5640 Ellis Avenue, Chicago, IL, 60637. **Linking microbial community metabolism to ecosystem phenotypes in aquatic environments.**

The rapid development of high-throughput sequencing and "omic" technologies (metagenomics/metatranscriptomics), have fundamentally altered our ability to determine "who is there" (community structure, biodiversity, and interactions) and "what are they doing" (functional activities or physiological processes) in microbial ecosystems. As a result of this data bonanza, new modeling tools have been developed that allow us to link changes in taxonomic composition and community functional potential with relevant environmental parameters (e.g nutrient concentrations, temperature, pH). We will discuss the virtue of longitudinal analyses in aquatic ecosystems, and the potential for these datasets to transform our understanding of microbial dynamics. In addition, we will show how modeling tools have enabled us to extrapolate predictions on the microbial dynamics of aquatic ecosystems. The combination of metagenomics and ecosystem community predictive tools, coupled with the data derived from Great Lakes environmental monitoring efforts, could provide insights on the biogeochemical cycles occurring in this ecosystem and will help to predict ecosystem changes in response to contaminants, cyanobacteria blooms, invasive species etc. An improvement on the assessment of the ecosystem status will have direct impact on management practices. *Keywords: Computer models, Next generation sequencing, Microbiological studies, Omic approaches, Metabolism.*

ZEIN, M.A.[1], MCELMURRY, S.P.[1], KASHIAN, D.R.[2], SAVOLAINEN, P.T.[1], and PITTS, D.K.[3], [1]Dept. Civil & Environmental Engineering, Wayne State University, Detroit, MI, 48202; [2]Dept. Biological Sciences, Wayne State University, Detroit, MI, 48202; [3]Dept. Pharmaceutical Sciences, Wayne State University, Detroit, MI, 48202. **Evaluating a novel optical bioassay for measuring sub-lethal toxicity in *Daphnia Pulex*.**

Many contaminants of emerging concern (CEC) tend to be biologically active at very low concentrations, occur in water as part of a complex mixture and impact biota in ways that are not detected using traditional toxicity tests (e.g., LC50). To better evaluate CEC we have developed a high throughput assay that can detect sublethal behavioral effects by quantifying the swimming behavior of *Daphnia Pulex*. This optical tracking technique measures several swimming parameters including: distance, velocity, acceleration and angular change. To validate this new technique we investigate 3 model compounds that exhibit different modes of action. The acetylcholinesterase inhibitor (AChE-I), physostigmine, was used as the model compound for the large number of AChE-I insecticides. Nicotine was used as the model compound for neonicotinoid insecticides and methoprene was used to characterize the effect of molt inhibitors. Results show this assay is capable of detecting sublethal effects that are concentration dependent. For example, physostigmine increased mean swimming distance significantly at low concentrations (< 1uM), but this effect declined at higher concentrations, where a paralytic-like response was observed. In addition to model compounds, complex mixtures and other non-

insecticide CECs will also be discussed. *Keywords: Pharmaceuticals, Water quality, Contaminants of emerging concern, Biomonitoring, Daphnia, Toxic substances.*

ZENOBIO, J.E.[1], SANCHEZ, B.C.[2], ARCHULETA, L.C.[2], LEET, J.K.[1], and SEPULVEDA, M.S.[1], [1]Purdue University, Department of Forestry and Natural Resources, West Lafayette, IN, 47906; [2]U.S. Fish & Wildlife Service, Environmental Contaminants Program, Lakewood, CO, 80236. **PPCPs Emerging Contaminants on the Baca National Wildlife Refuge, Colorado: Presence and Effects on Native Fish.**

The presence of pharmaceuticals and personal care products (PPCPs) in surface and ground waters has raised substantial concern. These chemicals, including natural and synthetic hormones, appear in mixtures at very low concentrations. The Baca NWR, Colorado is home to several endemic fish species. Within the last century, these fish species have been extirpated from much of their normal range and thus are considered vulnerable or threatened. Water from creeks inside the refuge was collected in summer 2011 and 2012 to quantify PPCPs and evaluate its potential impact to fish communities. We focused on fathead minnows, since they are a well-studied fish model for ecotoxicological research. POCIS samplers were used to estimate the cumulative aqueous exposure to hydrophilic organic chemicals, providing time-weighted average concentrations. We quantified 120 analytes and examined their effects in fathead minnows using histological analysis of gonads and liver. Additionally, we measured the expression of six genes involved in sex differentiation and reproduction (cyp19a, star, dmrt1, ar, erα, vtg). Preliminary results of water chemistry from POCIS samplers showed higher concentration of DEET and thirteen pharmaceuticals. In terms of effects, we observed ovarian and liver lesions and a significant decrease in dmrt1 and ar expression. *Keywords: Environmental contaminants, Pharmaceuticals, Fish, Genetics.*

ZHAO, J. and YERUBANDI, R., 867 Lakeshore Rd., Burlington, ON, L7R 4A6. **Modeling the effects of climate changes on the physical conditions of Lake Winnipeg.**

Future climate change is potentially an enormous risk to Lake Winnipeg ecosystems by changing the physical conditions in the lake, most simply the dynamics of water temperature. A three-dimensional hydrodynamic modeling system (ELCOM, Hodges and Dallimore, 2006) is applied to estimate changed physical conditions of the lake under projections of climate change. To assess the model performance, we simulate the circulation and temperature distribution of the lake in 2007 and compare the model results with the observations made in the lake. The model showed considerable skill in reproducing the thermal structure, surface currents and water levels. The model was then applied to baseline condition in 1999 and future climate in 2069 based on climate forcing from CRCM. Modeled water levels, temperatures in the baseline and projection scenarios were presented to show the changes of physical properties in response to changed climate. *Keywords: Climate change, Hydrodynamic model, Lake Winnipeg.*

ZORN, M.E.[1], KLUMP, J.V.[2], WAPLES, J.T.[2], VALENTA, T.[3], and KENNEDY, J.[3], [1]UW-Green Bay, Green Bay, WI; [2]UW-Milwaukee, Milwaukee, WI; [3]Green Bay Metropolitan Sewerage District, Green Bay, WI. **Determination of dissolved phosphate and nitrate in Green Bay, Lake Michigan using continuous monitoring, in situ chemical sensors.**

Green Bay, Lake Michigan is severely impacted by excessive nutrient inputs from its upstream watershed, and it has suffered from hypereutrophic conditions for decades. The majority of the nutrient load enters through the Fox River and its tributaries. The bay of Green Bay, the Lower Fox River Basin, and most of its tributaries are classified as impaired waters - a condition that has persisted for a long time with little or no improvement. The hypereutrophic conditions in Green Bay have a number of associated problems, including: excessive algae growth, harmful algal blooms, decreased water clarity, etc. These conditions have led to decreases in dissolved oxygen concentrations when excessive organic matter decomposes, resulting in recurring seasonal (summer) hypoxic conditions (< 2 mg/L dissolved oxygen), low benthic diversity and significant "fish-kill" events. In this study, concentrations of dissolved phosphate and nitrate were determined from early summer through mid-fall 2012 at a location in lower Green Bay using continuous monitoring, in situ sensors. It is likely that temporary stratification, followed by turnover (mixing) events may be largely responsible for the observed trends in nutrient concentrations. Meteorological factors (e.g., wind speed and direction, precipitation, etc.) may also play a role in the process. *Keywords: Nutrients, Sensors, Green Bay.*

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